HUMAN DEVELOPMENT – DIFFERENT PERSPECTIVES

Edited by **Maria Lucia Seidl-de-Moura**

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Contents

Preface

Human development has different meanings depending on the area we will focus on. It is the ontogenetic process of individual development for psychologists. It considers systematic psychological changes in several areas, such as motor, cognitive, emotional, social, that occur in human beings over the course of their life span. To sociologists and economists, among others, human development is the consideration of the macro-level countries or regions and their development conditions related to human needs. In a way it is oriented towards analyzing factors related to the quality of life in those countries or regions. In this sense it can be viewed as the process of achieving an optimum level of health and well-being, including physical, biological, mental, emotional, social, educational, economic, and cultural components. Some of these are expressed in the Human Development Index (HDI), a composite scale which has three dimensions: life expectancy at birth, adult literacy rate and mean years of schooling, and income as measured by real gross domestic product per capita.

L. S. Vygotsky (1896-1934), one of the classical authors in developmental psychology, has proposed that human phenomena should be studied taking into account their genesis (Vygotsky, 1978). He described several levels of analysis to this endeavour: phylogenetic, cultural history, ontogenetic and micro-genetic. Another researcher from the last century, U. Bronfrenbrenner (1917-2005) has proposed the "Ecological systems theory". His model includes several levels of context or systems in which human development occurs: the microsystem (such as the family or the daycare center); the mesosystem (two or more microsystems in interaction, i.e. family and daycare center); the exosystem (external environments which indirectly influence development, e.g., parental workplace); and the macrosystem (the larger socio-cultural context). This author (Bronfrenbrenner, 1979) suggests that basic science needs public policies. In this direction he was one of the co-founders of an enrichment program for preschoolers in the United States, called Head Start. Thus, based on those two authors, I think that not only it is possible but necessary to try to integrate the two perspectives of human development mentioned in the beginning of this chapter: the ontogenetic (considering the micro and mesosystems) and the socio-economical (including the macrosystem).

Besides those theoretical assumptions, in my decision I was influenced by a specific set of evidence from a large cross-national study on the "Value of children" (Trommsdorf, 2009). The study started in the 1970's aimed originally to study fertility changes and it

was conducted by demographers and economists. The first results indicated that fertility behavior was not explained uniquely by socio-economical factors. Psychological factors, such as motivation, needs, cultural and individual values were significant variables in this explanation. This has lead to a large international study involving nine countries under the leadership of a Turkish psychologist C. Kağitçibaşi, which has been replicated recently. The focus of the study was on explaining differences in fertility taking into account cultural and psychological factors. It was observed that the value of children (economic / utilitarian; emotional and social normative), or the motives to have them, vary according to economic conditions and the welfare system of the countries. In poor countries children have more economic value whilst in wealthier countries their value is more emotional. Results have also shown the relation between value of children and parental goals and practices, thus reflecting in child development. We can see how the two aspects of human development contemplated in this book are related. Thus, the book has two parts. The first part is entitled "Development in the Ontogenesis" and it consists of three chapters whilst the second is "Human Development: Contextual Factors", including also three chapters.

The first part of the book starts with the chapter in which Maria Lucia Seidl-de-Moura and Deise Maria Leal Fernandes Mendes discuss "Human development: The role of biology and culture". They present contemporary tendencies of Developmental Psychology, the concept of development in the ontogenesis and basic assumptions to study it. A life cycle perspective is taken in an evolutionary and socio-cultural orientation, aiming to understand ontogenesis as based in our phylogenetic history and occurring in specific socio-cultural and historical contexts. The inseparable relation between biology and culture is highlighted. The importance of a consideration of groups is also discussed, beyond specific Anglo-Saxon North American and European ones, but from the majority world. Recent research is presented and discussed in different aspects of development, as examples of the perspectives adopted.

The second chapter in Part 1 is written by Arnulf Kolstad and follows the same direction as Seidl-de-Moura and Mendes. Based on Vygotsky's perspective and recent research following his tradition, it discusses the "Interfunctionality between biology, culture and mind: a new paradigm for human development". The chapter is about the epistemology of psychology. It focuses on how higher psychological functions (i.e. human cognition, emotions and, motivation) develop dialectically from a biological basis and how the brain changes due to conscious mental and physical activity in a specific culture. The author argues that higher psychological functions are constructed as individuals participate in social interaction and are therefore culturally dependent. To understand biology, culture and mind as dialectically related is crucial for comprehending human development and for establishing a reasonable psychological epistemology.

The third chapter deals with motor development in a dynamic systems' perspective. It is a very original contribution from Üner Tan, entitled: "Development of bipedal and

quadrupedal locomotion in humans from a dynamical systems perspective". In his chapter Dr. Tan demonstrates that human quadrupedalism may emerge during infantile locomotor development in otherwise healthy children or those exhibiting the Üner Tan syndrome. He considers that neural networks responsible for quadrupedal locomotion have first emerged nearly 400 million years ago, resulting from the process of self-organization with rewiring of the nervous system. He uses the dynamic systems theory to discuss how the development of the attractor, human quadrupedalism, as a self-organized motor behavior, may result from the dynamic interactions of many subsystems. Among these, he cites the spinal central pattern generators, posture, balance, body constraints, muscle strength, extensor and flexor motor systems, perceptual processes, cognition, motivation, genetics and environmental constraints. This condition does not depend on the prior existence of instructions embedded within the genes or the neural circuits within the central nervous system. Besides describing this unique condition that the author has extensively studied, the chapter presents a very good introduction to the dynamic systems theory.

The second part of the book, "Human development: The context to ontogenesis", consists of four chapters. The first chapter "Partial and fractional mobility: A proposed study in the dynamics of Human Development" is written by Atanu Sengupta and Abhijit Ghosh . The authors focus on dynamic changes in HDI (Human Development Index) and propose a new model to analyze it, using the concept of fractional mobility. They develop a set of mobility indices from this framework and provide an example using data on individual countries. HDI is an important measure of life expectancy, literacy, education, and standards of living for countries, states, cities, villages. It gives information about the impact of economic policies on quality of life and well-being in a context and it is related to child welfare. The phenomenon is not static and suffers dynamic changes. This chapter brings a significant contribution to the measurement of those changes.

The second chapter is also about context changes. Alam Shaista aims to answer the question: "Does environmental degradation affect human development and sustainable economic development? The case of Asian developing countries". The chapter discusses the long run effects of environmental degradation and major socio-economic and demographic factors on quality of human development in Asian developing countries. Important factors such as poverty, access to safe drinking water, trade openness, foreign direct investment, external debt burden, and population density. are included. The chapter also estimates the effects of environmental degradation and other socio-economic and demographic factors on sustainability of economic development in those countries. The analysis provides data about an effective and efficient macroeconomic policy framework to prepare long term strategies for sustainability of economic development and quality of human development in Asia. The contribution can be extended to other developing countries and provide information aiming to enhance human development and quality of life.

The development of appropriate policies in this direction can constitute positive initiatives to improve the contexts of ontogenetic development in developing countries, or as Kağitçibaşi (2007) prefers to refer "the majority of the world".

The third chapter covers the continent of South America. Juliana Souza Oliveira; Pedro Israel Cabral de Lira and Malaquias Batista Filho discuss: "Food and nutritional insecurity state in the population of accented degree of poverty in the northeast of Brazil". The authors compare the situation of the two Brazilian localities which present adverse socio-economic characteristics, including low family income and maternal educational level, and unfavorable housing and sanitation condition. The two localities have different ecological characteristics. Gameleira presents the best agricultural conditions (with a monoculture of sugar-cane) and the longest regular periods of rainfalls in the Northeast, but at the same time the highest index of food insecurity and the lowest nutritional status of their children. The second locality (São João do Tigre) is located in the semi-arid region, with poor soils, irregular and scarce rainfall, low level of technology and a system of family labor basically developed for self consumption. Although some of the conditions are worse than in Gameleira, the food security situation is more favorable. The authors discuss those results in terms of distinct economical and social conditions: the landowner monoculture plantations focused in the foreign market vs small family land units. They have observed that the food insecurity condition of the two populations' contrasts with favorable anthropometric normality in children, characterizing what they call a "peculiar moment of fast nutritional transition process in Brazil". This situation may be related to public policies of the Brazilian government. It seems that the inequality still present and high in the country may be diminishing and bringing some consequences that may have impact on nutritional status, HDI and the development of children.

In the second part of the book, the contexts from Asian and South American - "majority world" were considered. Poverty, disease, food insecurity and their consequences on human development were discussed. Those are not the aspects and contexts discussed in the textbooks in Developmental Psychology. However, in order to study human development in the psychological sense, we need to consider the contexts in which this process occurs. The contributions of the second part of this book are very important. Together, the two parts give the readers a panoramic view of very complex subjects and they have a common theme: change. Ontogenetic development in the life cycle is about the change of behavior, structure, organization as a result of epigenetic processes. Human development of countries and regions is not static and it can change, for worse (due to the spread of HIV/AIDS, for example), but also for better as the authors have discussed in the second part of this book.

The topics addressed in the six chapters may not be equally familiar to all kinds of readers. Some will be more interested in the development of individuals in its varied aspects. Others will focus their attention mostly on the technical reports of macro-contextual data. However, the two parts complement each other. Taking Vygotsky's advice and Bronfenbrenner's model into account, researchers of ontogenetic

development cannot ignore that contextual factors are the basis of this process. Nutrition, mortality rates, quality of life reflected on the HDI of a country or region will influence directly or indirectly on how individuals who live in those contexts develop along their life cycle. On the other hand, social scientists worried about those macro variables need to remember that they are dealing with people, who are affected one way or another by those variables and whose development is the product of biology and culture.

In the end, I am glad that I have accepted to edit this book and I am sure it brings a contribution to readers from many areas. I hope they find it useful.

Dr. Maria Lucia Seidl-de-Moura
University of the State of Rio de Janeiro
Brazil

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Section 1

Development in the Ontogenesis

1

Human Development: The Role of Biology and Culture

Maria Lucia Seidl-de-Moura and Deise Maria Leal Fernandes Mendes
University of the State of Rio de Janeiro
Brazil

1. Introduction

This chapter discusses contemporary tendencies in Developmental Psychology, the concept of development in ontogenesis, and basic assumptions to study them. We assume a life cycle perspective from an evolutionary and social-cultural orientation. This perspective aims at understanding ontogenesis as based in our phylogenetic history and occurring in specific social-cultural and historical contexts. The inseparable relationship between biology and culture is highlighted, and we discuss the importance of considering groups from the *majority world,* beyond specific Anglo-Saxon North American and European ones. Recent research on different aspects of development are presented and discussed as examples of the perspectives adopted.

2. What is development?

Human development is a multidimensional process, involving considerable variation in both the direction and functionality of changes throughout life course, including gains and losses in all its phases. It is not a linear movement towards progress, increase of efficacy or growth, but involves basically transformations. It moves from conception to death, including an intra-uterine phase, and the period after birth. No single period in this process can be considered to be more important than the others (neither infancy nor adult age, for example) (Baltes, 1987). The task for researchers in this area is to look for the available capabilities and the limits imposed at different moments in the process, balanced by the plasticity of individual development.

According to Cole (1998), development involves the emergence of new forms and functions of interactions among people and their worlds. It is the result of the articulation of two different paths that follow different patterns of change: phylogenesis and cultural history. Human babies are born with a biological organization resulting from our philogenetic history (Seidl-de-Moura & Ribas, 2004). Through an epigenetic process (Cole, 1998), genes interact with the environment. Successive forms and patterns of interaction between the organism and the environment emerge and the result is the human newborn baby. At the same time, human babies are born in an environment that is the result of cultural history within a historical time. They are born *bathed* in culture and are part of it. We can observe this in the different traditions presented when a baby is received in his / her family. In Brazil, the hospital room door is

usually decorated according to the baby's gender, family preferences, and even the fathers and mothers' soccer team. The expectations are clearly stated in the decorations and a socialization trajectory is somewhat demarcated at this moment. Obviously, this trajectory starts to be delineated even earlier, when a baby is planned or the mother is expecting. Thus, culture allows for development and circumscribes it. As Bussab and Ribeiro (1998) and other authors from an evolutionary perspective, Cole (1998) considers the baby to be both a biological - born with adaptive characteristics – and a social being.

Individual development is the result of a probabilistic process. It is not entirely predictable, but is rather the result of the dynamic articulation among diverse influences, such as the physical, social and cultural characteristics of the environment, genetic predispositions and propensities, neural activity, and individual experiences and behavior. Human babies' first experiences are intra-uterine, when they move in their mothers' uterus, and hear their voices and others'. These experiences are unique and they enter in this non-linear equation of influences. Bjorklund and Pellegrini (2002a & b) propose a systemic perspective to explain ontogenetic development, including genes and both the organisms' internal and external environments. What gets transmitted, according to these authors, is not only genetic information, but also development interacting resources (such as genes, the necessary apparatus for their functioning, and a larger context of development).

Bjorklund and Pellegrini (2002a & b) consider that it is not only a species' specific genome that is inherited by humans, but also a typical environment, even with all the apparent variations that characterize it. Some examples of characteristics of this typical environment are pregnancy, nursing, necessary care resulting from our altricial condition, and etc. This environment is a system of contexts partially fitted in different levels, from micro to macro. Organisms and contexts interact in different forms throughout the life cycle. There are specific tendencies for certain behaviors or mechanisms, such as attachment, which are characteristics of the species. However, the form through which these mechanisms express themselves varies, depending on the environment or ecological conditions experienced in certain moments of development, which also vary. These conditions can be described as developmental niches (Harkness & Super, 1996), which include three interrelated subsystems: the social and physical environment in which the individual lives; the shared practices of care, and the psychology of the caretakers.

As mentioned above, human development is markedly influenced by cultural conditions in a specific historical period and by the direction in which these conditions change. According to this perspective, the course of ontogeny is shaped by these circumstances, by the macro and micro social contexts, as well as by individual temperament. The idea of development as a process is crucial because it focuses on changes and relations at different moments, rather than only focusing on products of development. In order to understand human development it is necessary to take into account not only the relationship between biology and culture, but also the inseparability of different planes of analysis: philogenetic, ontogenetic, historical-cultural, and microgenetic (Vygotsky & Luria, 1996). From this assumption, considering development in ontogenesis is to think of a process that occurs in a historical time, within a specific context, and which is a product of evolution by natural selection throughout our constitution as a species.

In studying behavioral development it is also important to attend to the four questions proposed in ethology by Tinbergen (1963): 1) *what are the stimuli that elicit the response, and*

how have them been modified by recent learning? How do behavior and psyche "function" at the molecular, physiological, neural-ethological, cognitive and social level, and how do the relations between the levels look like? (Questions related to the proximate mechanisms - the immediate influences in behavior); 2) *how does the behavior impact animal's chances of survival and reproduction? What are the selective advantages?* (Questions related to function of behavior or adaptation - the adaptive purpose); 3) *how does the behavior change with age, and what early experiences are necessary for the behavior to be shown? Which are the developmental steps (the ontogenesis follows an "inner plan") and environmental factors that play when / which role?* (Questions related to the ontogeny - the developmental influences in behavior); 4) *how does the behavior compare to similar behavior in related species and how might it have arisen through the process of phylogeny?* (Questions related to the phylogeny - the evolutionary or philogenetic origins of behavior).

One final aspect to be considered is the object of study in Developmental Psychology, and its possibility of generalization. Tomlinson and Swartz (2004) pointed out that 95% of studies on infancy conducted from 1996 until the time of their review are from Anglo authors. In contrast, at the time of their publication approximately 135 million babies had been born in the world, approximately 90% of them in "third world" countries, which we can consider the *majority world*. One can infer the implications of this bias in the construction of knowledge on human development.

Henrich, Heine and Norenzayan (2010) discuss the question raised above, based in a broad review in psychological literature. The authors claim that evidence in general behavioral science is often concentrated in data from a very specific group of subjects, who they label WEIRD (western, educated, industrialized, rich and democratic groups). They are Western educated, high social-economical level subjects, from industrialized countries, frequently psychology undergraduate students. They notice that researchers assume, either implicitly or explicitly, that these evidences can be generalized to other members of the species in general, especially data from psychological "basic processes". Their review indicated that 96% of the samples in psychological publications were from countries that represent only 12% of the world population. Even in these countries the chosen samples are not representative of the population, since they are many times composed by psychology students. This can lead to serious distortion, especially because authors are not cautious in their conclusions and generalizations. They aim at understanding and explaining the human mind or behavior using samples that not only are not representative of the population, but also may consist of a group of outliers.

In the review presented in the article (Henrich, Heine & Norenzayan, 2010) studies with adults are predominant, but they also point out that developmental research is biased towards focusing North American middle-class children. They cite studies in spatial reasoning and present evidences on gender differences, all of them found in high middle-class North American children, but not in ones from low SES or from non-urban contexts. Lancy (2010), one of the discussants of the main article, criticizes the ethnocentrism of developmental studies, mentioning evidences related to play, parents-children interactions, attachment and parental styles.

The perspective we propose to assume in our studies on human development takes into account the questions addressed above. It aims at understanding universal processes, but it assumes they occur in specific ecological and social-cultural contexts. Thus, knowledge

cannot be constructed based on evidences from restricted groups. The psychology of the *majority world* needs to be incorporated in mainstream Developmental Psychology. This has been the policy defended by the International Society for the Study of Behavior Development (ISSBD), which held its last scientific meeting in an African country, Zambia, part of this *majority world*.

3. Ontogenesis and phylogenesis: Evolutionary perspective on development

The conception of ontogenetic development presented here follows the perspective of developmental psychology oriented by the biology of evolution, which represents a recent tendency in the area, the perspective of the Evolutionary Developmental Psychology (EDP).

"We believe that the *zeitgeist* has changed, and we are pleased to be part of a growing group of developmental psychologists who see the possibility of an evolutionary-based theory of ontogeny that will encompass all who think seriously about development" (Bjorklund & Pellegrini, 2000, p. 341).

Ontogenesis is related to the history of our species. The development of individuals in the course of their life is based on the history of modern *Homo sapiens* and is a product of this history. Individual development varies according to limits and possibilities imposed by this history and by different cultural characteristics.

Although it is important to consider the evolutionary perspective on development, we emphasize that it does not exclude other contributions. Evolutionary Developmental Psychology (EDP) should be integrated and understood from a perspective that incorporates the recommendations of both Vygotsky (about considering in development the inseparability of different planes of analyses) and Tinbergen (1963).

Evolutionary Developmental Psychology consists in the application of the basic principles of the Theory of Evolution to explain contemporary human development. This approach is relatively recent and it aims at investigating the ways in which our evolutionary past influences the ontogenetic development of human beings (Bjorklund & Pellegrini, 2002a, b).

There are two main assumptions with heuristic contributions to Developmental Psychology, and which are related to evolutionary perspectives (Charlesworth, 1992). One of them is related to *individual differences* and is concerned to the physical and social environments. In this way, there are differences among children in relation to mortality rates, abuse, neglect, malnutrition, quality of care, and education. This condition of the presence of individual differences can be related to the immediate effects on children's health, life and development, and has repercussions in long-term survival and reproduction in adult life.

The second assumption is the notion of *typical characteristics of the species*. In human beings, these would be behaviors or motivations that tend to appear in different cultural and historical contexts (universal predispositions), mainly because of their high adaptive value. In other words, they are associated to the survival of individuals and their fitness. As a result of the long period of relative immaturity of human beings, it can be registered the following examples: parental care, which includes attachment and conflict between child and adult, interaction between siblings, moral development training, structure and functioning of groups of children with similar ages, which involves domination, submission, competition and cooperation, learning, among others.

Based on this perspective, we conceive the adult not as the final product of selective forces in evolution, but all life cycle. Human life cycle is organized through universal developmental tasks that need to be solved in specific ecological and social-cultural contexts. Due to environmental variability, traits and strategies throughout life cycle are not fixed or determined genetically, but evolve to show plasticity, that is, to maximize fitness in diverse ecological conditions. Culture and cultural acquisitions are adaptations, and they serve individuals' fitness.

4. Homo sapiens sapiens: "Biologically cultural"

It is commonplace to consider humans as a special species, or to think about ourselves as specials in comparison to individuals from other species. Although humans are proud of their nature and of their *unique* abilities, findings from diverse scientific fields (neuroscience, evolutionary biology, ethology, and others) demystify the idea that the human species is superior in many aspects to any other. Today we know, for instance, that humans and chimpanzees share 99% of their genetic material, other species can make use of what some consider a rudimentary type of language, some non-human primates use instruments, have culture and a sense of justice. In addition, we can be highly intelligent, but neither the human brain is the largest among the primates, nor humans have the largest encephalization quotient (Dolphins have larger ones).

As happens to other animals, humans have many adaptive capabilities resulted from selective pressures. However, what is wonderful is that we display characteristics that have evolutionary relationships to the cultural context, such as dependent childhood, parental investment, propensity to attachment, cooperation, complex language, and tendency to lasting connections between lovers. All of these characteristics seem to be crucial for our great capacity to deal with a diverse and complex world, in terms of its physical and social-emotional aspects. Although some primates have been known to have some rudiments of culture, certainly human beings are distinguished from other animals by their highly specialized cultural way of life. As mentioned before, humans are *biologically cultural* (Bussab & Ribeiro, 1998; Rogoff, 2003).

Based on the discussion above, it is surprising that biology and culture have been considered for centuries as opposite dimensions in human development. Since ancient times, philosophers and other scholars have shown great interest in how we acquire knowledge, how we can learn about things and people, and so on. Psychologists also have thought about these questions, investigating humans' mind and behavior. The attempts to answer these and other related issues often bring the dichotomy nature x nurture, genetic determination x environmental influence, biology x culture as an explanation for developmental processes.

The relationship between nature and culture is not simple and still needs to be better understood. Apparently, as soon as our ancestors developed a cultural dependence for survival, natural selection began to favor genes for the cultural behavior. According to Bussab and Ribeiro (1998), analyses of fossil records show an evolution *pari passu* between biology and culture, supporting the *cultural nature* of men. There is evidence that our supposed ancestors, the *Homo habilis* and the *Homo erectus*, had had a social-cultural way of life, inferred by a systematic use of manufactured stone tools, increase in social exchanges

and knowledge transmission. There are strong indications that the characteristics favorable to culture development and transmission were selected.

Some characteristics presented by human beings are at the same time selected by cultural context and favor cultural evolution. Therefore, this old discussion involving radically opposed positions seems to be ineffective and outdated. The challenge is to understand how they work together throughout the life cycle. Thinking about ontogenetic processes and the genesis of development can help us to move forward in this debate. As proposed above, we adopt a social-cultural and evolutionary perspective, which presupposes an interactionist position. According to this view, we are products of our genetic predispositions, which are updated in the environment.

Pathways followed by social interactions and parental care in ontogenesis are illustrative of these issues regarding biology and culture's roles in development. Human development is constructed through the individuals' social interactions with their co-specifics. These interactions are product of ecological and social-cultural conditions, and follow diversified socialization trajectories of development. In contrast, the tendency for interacting with others and the need for emotional warmth may be considered human predispositions. Keller (2007) proposes a cultural model of parenting to discuss how human beings are, since conception, oriented by certain predispositions or open genetic programs. From these programs they are able to have experiences that conduct to the construction of a modal conception of self.

The *Component Model of Parenting* is conceptually composed by six universal and independent systems (Keller, 2007). In different cultural contexts, caretakers emphasize this systems differently, both with respect to their care practices with their children, and to their beliefs and parental ethnotheories. In addition, their socialization goals are related to a cultural model and reflected in their practices, involving what they think is good for raising children.

The first of these described systems is *primary care*, considered phylogenetically the oldest system. It involves a set of activities that aim at meeting babies' survival needs, including health related activities, such as nursing, diapering, bathing, washing,, and so forth. The function of this system is to reduce stress and promote security and trust in relation to caretakers' protection. The second one is the *body contact system,* which promotes corporal contact, and involves carrying the baby close to the body. This system affects the bonding between mother and baby and group cohesion, and has the function to protect the baby from dangers and predators.

The *body stimulation system* is also based on communication through the body and involves any motor, kinesthetic, tactile and balance stimulation of the baby. Dyadic activities are exclusive, and this system's function is to stimulate motor development and to intensify corporal perception. The fourth system is *object stimulation,* and it has the goal to present the object world and physical environment to the child, and is related to exploratory activities.

Face-to-face context is characterized by mutuality through eye-gazing. It is promoted by the mother, when she places the baby in a position where their faces are close, so they can maintain eye contact. The frequent use of language and unique dedication in dyadic interactions are characteristics of this system. The *proto-dialogues* that happen between

mother and baby in this context provide the baby with the experience of contingent perception. Finally, the sixth system is the *narrative envelop,* which refers to the symbolic mediation that involves the infant through mothers' conversations. This system presents different styles according to cultural models.

Keller (2002) argues that according to the predominance of these parental systems and of interactional mechanisms, learning, based on open genetic programs, is translated into experiences that lead to a modal conception of self. This same author (Keller, 2007) also discusses about two contrasting modes of care. The first is a non-Western way, with multiple social environments (caretaking is shared) and co-active attentional structure. Mothers perform their daily activities carrying their baby. In contrast, in a Western, urban way, the social environment is dyadic and attentional structure is unique. In general, while the adult takes care of a baby, no other activities are simultaneously performed.

Interactional experiences are different in these two modes of care. In unique dyadic environment it appears to predominate an interaction style that focuses on visual communication and on oral/verbal exchanges. In the multiple social environments, in turn, the corporal contact between the mother and her baby is much greater, and the cues partners received from one another are tactile.

Socialization goals can be understood in relation to these two ways of parental investment. Urban Western cultures, in which babies spend much time alone, favor earlier autonomy. On the other hand, in most non-Western and non-urban cultures socialization goals emphasize close interrelationship between babies and their caretakers. This contrast is possibly a good example of an open genetic program, an innate tendency to parenting that is expressed in different modalities, according to specific ecological and cultural contexts. In theory, according to Keller (2007), these goals are related to practices and are correlated to different self development trajectories (We will return to this point ahead).

Evidence in this and other domains signal that being cultural is part of our biology, and that genetic heritage can only be expressed in specific ecological and social-cultural conditions, hence describing the epigenetic landscape of potential developmental pathways.

5. The interaction between biology and culture: Investigations and evidences

Parental investment and care

Life history theory focuses on strategies employed by organisms to allocate their time and energy to deal with different demands throughout their life-cycle. These demands include various trade-offs between somatic effort (aiming survival) and reproductive effort (and within it between mating and parenting). Parenting involves a complex dynamics that mobilizes cooperation and conflict, different kinds of emotions and strategies. As the other aspects discussed in this chapter, parenting is the product of both biology and culture. Biologically, it is basic for individuals' (parents and children) fitness, but the form it takes is varies (Keller, 2007). Human babies are born dependent on care for their survival and future reproduction. Despite individual variations, they are born with a set of characteristics that attract adults who care for them and that predispose them (babies) to interact with their co-specifics, as mentioned previously. On the other hand, adults are capable of caring for infants and they are oriented by the dynamic of investment in their offspring. Since life

history strategies are not fixed, but rather evolve to show adaptive developmental plasticity, parental investment and care can assume different forms. Local environments and ecological conditions are automatically assessed by parents and are crucial for the adoption of diverse strategies of investment and care.

The *Component Model of Parenting* proposed by Keller (2007) sets predispositions of care in terms of parental systems. The organization of these systems in response to ecological conditions is translated into some basic socialization trajectories. Such trajectories have been described as moving towards the socialization of either autonomous/independent selves or towards interdependent selves. Findings in several cross-cultural investigations, carried out by Keller and her colleagues (Keller et al., 2006; Keller et al., 2007; Keller, Borke, Lamm, Lohaus, and Yovsi, 2011; see also Keller, 2007), are representative of these notions of different trajectories of development of the self. In these studies, Keller and colleagues analyzed general orientations concerning parental beliefs, and values among parents of several distinct cultures (German, Euro-American, Greek, Indian, Chinese, Mexican and Costa Rican).

In one of the most recent study (Keller et al., 2011), two prototypical socialization contexts of independence (autonomy) and interdependence were addressed: German middle-class families, and Cameroonian *Nso* farming families. The results confirmed the expectations in identifying two different parental styles. German babies experience significantly more face-to-face contact in free-play interactions in the first three months of life than do the *Nso* babies. *Nso* mothers perform significantly and consistently more body contact from the beginning than German mothers. It was also confirmed the hypothesis that face-to-face contact and autonomous discursive style are positively correlate, while face-to-face context and style of relatedness are negatively correlated over time. Results still showed that body contact and style of relatedness are positively correlated, while body contact and autonomous style are negatively correlated. These correlations validate body contact and face-to-face contact as supporting different socialization strategies.

Considering agency and personal distance, Kagitçibasi (2007) has added the trajectory towards an autonomous-relational self to the two proposed by Keller (2007). Data from Brazilian studies on socialization trajectories showed this mixed trend, and indicated the importance to take in account intra-cultural differences in studying development.

One study conducted with 350 primiparous Brazilian mothers, from the five geographic regions of the country, aimed to investigate their socialization goals (Seidl-de-Moura, Lordelo et al., 2008). The Socialization Goals Interview (SGI), adapted from Harwood (1992) was used. Answers to the instrument were coded in five categories: Self-maximization, Self-control, Lovingness, Proper Demeanor, and Decency. The results showed that Brazilian mothers gave more emphasis to Self-maximization and Proper Demeanor than to other categories, presenting a pattern that fosters the development of children's autonomous-relational selves. Intra-cultural variation was found among the different cities studied, and the three different cultural models described in the literature were identified, indicating that there is not homogeneity in Brazilian mothers' socialization goals.

In a different study, parenting cultural models of a group of 200 primiparous mothers from Rio de Janeiro, Brazil, were studied in terms of systems of beliefs and practices (Seidl-de-Moura et al., 2009). Participants had children less than 44 months-old. Mothers answered the

Socialization Goals Interview (SGI), and an adapted version of an inventory on beliefs about care practices, developed by Suizzo (2002). Answers to the SGI were coded in the five categories listed above, and scores in each of them were calculated. A factor analysis indicated three dimensions in mothers' beliefs about practices: awaking and exposing the child to diverse stimuli (Stimulation), ensuring the Proper presentation of the child, and Responding and bonding to the child. Results showed that mothers from Rio de Janeiro share a cultural model of autonomy for their children, but they also believe in the importance of their children's relationship to others, which reinforces the findings of Seidl-de-Moura et al. (2008a).

A different study on mother-infant interactions (Seidl-de-Moura et al., 2008b), conducted with dyads in Rio de Janeiro, Brazil, brings evidences on socialization goals and practices. Analyzing characteristics of interactional instances in two groups of dyads (N=56), the authors reported the prevalence of face-to-face interactions when the babies were one month old, and of object stimulation when the babies were five months-old. Based on Keller's (2007) model, the pattern observed is characteristic of a socialization trajectory that emphasizes the development of autonomy and independence, in contrast to a trajectory in which body contact and body stimulation are prevalent. The mothers studied seem to value goals of autonomy and independence, while also holding sociocentric goals.

Vieira et al. (2010) also aimed to investigate characteristics of Brazilian mothers' beliefs system in the dimensions of autonomy and interdependence. One group of 600 women, half from state capitals and half from small towns, participated in the study. They were individually interviewed using Scales of Allocentrism, Beliefs about Parental Practices and Socialization Goals. The results indicated that although mothers from both contexts valued autonomy, those living in small towns considered the relational dimension as the most important, whereas mothers living in capitals equally valued both dimensions, either in their beliefs about practices or in the socialization goals for their children. Mothers from small towns have a higher mean score on allocentrism than mothers living in capitals. Thus, place of residence proved to be a relevant variable in modulating maternal beliefs. In contrast, educational level was not a significant factor in the variables considered and with this group of mothers.

The results in these studies contribute to the understanding of the relationship between dimensions of autonomy and interdependence in mothers' beliefs system. They also confirm the idea of a high complexity in parenting models, which are simultaneously the product of cultural demands and the expression of predispositions for care.

Attachment and relationship style

Attachment theory (Ainsworth, 1988; Ainsworth & Bowlby, 1991; Bowlby, 1969/1984a & b) considers human beings to have the tendency to form emotional bonds with certain individuals as a basic component of human nature, present since birth. As a universal feature, this is understood as having patterns of adaptive innate behaviors, which have the function of ensuring care and protection to children. These patterns of behavior and reactions are generally considered the same for all individuals, independent on the context.

The theory is based on ethology and evolutionary concepts. In its original formulation, attachment is considered a disposition to search for proximity and contact with a specific

figure, establishing a sense of security. This species' tendency has an important biological function, since we are a semi-altricial species and the survival of infants depends on the proximity of adults who provide food, protection, and comfort.

Bowlby proposed control systems - attachment, fear, affiliative and exploratory -, each of them with important functions. The attachment system has the function to ensure that children bond with persons who will provide care and protection against predators. Fear involves the avoidance and distancing from threatening situations. Although it is essential for survival, it has to be balanced by a system that allows children to interact with co-specifics with whom they do not have attachment bonds. This is the function of the affiliative system, which allows children to explore the social world. Finally, it is also adaptive that the child knows the surrounding environment, which is a function of the exploratory system. Exploratory behavior is activated by novelty (Bowlby, 1969/1984a & b), and what determines the end of its action is familiarity to what has been explored. This is the process we call habituation. Control systems act dynamically (Barnett & Vondra, 1999), and their different activation levels interact. For Bowlby and colleagues who follow attachment theory, healthy development depends on the balance between functioning of the diverse systems.

The process of establishing attachment relationships starts at birth and uses mediator behaviors that make the attachment figure move towards the child or vice-versa. In the first case, for instance, when the child cries, smiles, babbles, makes gestures, she/he propitiates mother's proximity. In the second case, behaviors of the child bring him/her closer to the mother, such as walking in her direction, follow or grabbing her. According to Bowlby (1969/1984a & b) the child develops internal functional models, which are mental representations of the availability of attachment figures. The need to develop attachment relations is universal, but there are individual variations related to the child and to the adult sensitivity.

Attachment theory has been widely accepted in its original formulation. Based on its propositions, children can be classified as presenting different patterns of attachment according to their performance in the *Strange situation*, an evaluation setting developed by Mary Ainsworth (1989). Attachment quality has been classified as secure, insecure, insecure/avoidant, and insecure/ambivalent. Some include also disorganized, avoidant/ambivalent, and unstable/avoidant styles (Barnett & Vondra, 1999; Waters & Valenzuela, 1999). The evaluation setting focuses on the child's reaction to mother leaving the room, the presence of a stranger and the mother's returning. Seidl-de-Moura and Ribas (2004) have reviewed the literature on cross-cultural studies on attachment and have concluded that attachment theory needs to be investigated in different social-cultural contexts, in order to be assessed in regards to its limits and to receive a trans-cultural validation.

Along these lines, recent research has shown that different patterns can be adaptive depending on local conditions and cultural contexts, and that distinct historical moments can produce different attachment patterns (Keller, 2008). Evidences are challenging the idea that the secure attachment pattern, as observed by M. Ainsworth, represents a universal norm. Implicit in this idea is the definition of independence and autonomy as conditions for healthy human development. However, as discussed above, socialization trajectories and adaptive strategies vary in different conditions and cultural contexts. The reaction to people they do not know is diverse according to the way babies are raised, as Otto (2008, in Keller,

2008) has demonstrated with African *Nso* babies. Research shows that the most adaptive emotional regulation strategies for some children from non-urban and non-Western societies are not the same as those considered as secure attachment for Western middle-class infants (Otto, 2008, in Keller, 2008).

Chisholm (1996) has proposed that varied attachment patterns may have adaptive functions. When parents are willing to consistently invest in their children, but with scarce resources, the pattern of insecure-ambivalent attachment maximizes the available investment, indicating needs for care, immaturity, and dependency. On the other hand, when parents are not willing to invest, developing insecure-evitative attachment, emotional distancing and independency from parents reduce the child's demands to them. This will reduce risks of abuse or abandonment while the child is still vulnerable.

Thus, while predisposition for attachment may be innate, different experiences in interactional history determine an infant's development of either emotional security or insecurity in attachment relationships. The way this is manifested depends on the adaptive value of the child's behavior and on culturally defined beliefs and practices of care.

Emotional expression

One other example of our argument on the relationship between biology and culture is emotional expression. This is one of the controversial issues related to human emotion, and the discussion on whether facial expressions of emotions are universal or culture-specific goes back more than one century. There are those who claim that facial expressions of emotion are universal across human cultures and thus biologically determined. In contrast, there are those who defend these expressions to be cultural in their origin. For these scholars, such expressions are analogous to language, once they functions as a means for communication, and that they must be learned. However, this is not a simple question and intermediate views certainly exist.

Publications from Silvan Tomkins and Robert Plutchik on emotions gave origin to many studies about facial expressions of emotion from the 1970s. Recognized researchers in this area as Paul Ekman and Carroll Izard developed theories, methods and evidences that constitute what became known as *Facial Expression Program,* focusing on the universal, *basic* emotions, which are assumed to be the cause and the signal received from facial expression. This program generated a huge set of evidence (Ekman, Sorenson, & Friesen, 1969, Ekman, 1972, lzard, Huebner, Risser, McGinnes, & Dougherty, 1980, see also Ekman, 2003 and Izard, 1971).

The interest in investigating the origins of emotional expressions considering the controversy between nature and nurture is present in the work of Ekman. After conducting different cross-cultural researches, he claimed that in contrast to the belief of some anthropologists, including Margaret Mead and Ray Birdwhistell, and even of some psychologists as Otto Klineberg, facial expressions of emotions are not culturally determined, but universal across human cultures, and thus biological in origin. According to him, a large body of evidence reinforces this view (Ekman et al., 1969; Ekman, 1972; Ekman, 1994).

Ekman (1999) believes that is reasonable to propose that what is universal in facial expressions of emotions is the connection between particular facial configurations and specific emotions. However, the ways in which this universal connection between

expression and emotion is established is not yet satisfactorily answered. For many investigators, it is likely that this connection gets established through natural selection. For others, in turn, it cannot be ruled out the possibility that some of these expressions are acquired through species-constant learning. One might ask whether it is reasonable to think that the pathways of learning are not associated to predispositions and species-specific adaptive mechanisms, freely following in either direction.

Discussion around the expression of emotions continues, and it is hard to agree on how many different expressions are universal for any given emotion, although there is evidence to suggest that there is more than one universal expression for each emotion. In a similar way, it is also not certain how many emotions have a universal facial expression (Ekman, 1999).

Contributions from Carroll Izard also deserve attention. His Differential Emotions Theory (DET), and the Maximally Discriminative Affect Coding System (MAX) have inspired many studies. DET maintains that universally recognizable innate, basic emotions emerge within the first two to seven months of post-natal life (Izard, et al., 1995), and argues for the congruence between emotion expression and subjective experience (Izard & Abe, 2004).

Despite the evidence for the universality of emotional expressions, there have been challenges to this perspective, including James Russell's studies on how words are used to judge photographs of facial expression. He is one of the most prominent critics of universals in facial expressions of emotions. Although he believes that facial expressions and emotion labels are probably associated, this association may vary between cultures and it is loose enough to be consistent with various alternative explanations (Russell, 1995).

Within the area of emotional development there have been perspectives that consider basic emotions to be innate. However, these views present some difficulties in dealing with the emergence of new emotional forms, particularly in initial development. Some perspectives have emerged more than a decade ago, and were exposed in a symposium of the *International Society for Research on Emotions*, in 1996. Alan Fogel, Klaus Scherer, Linda Camras, Marc Lewis and others defended the approach of emotional self-organization based on the *Theory of Dynamic Systems*, and were interested in finding best alternatives to deal with the issue.

Studies with infants, children and adults discuss the universality, as well as the cultural diversity in some patterns of emotional expression (Kitayama, Mesquita, & Karasawa, 2006; Matsumoto, Willingham, & Odile, 2009; Trommsdorff, Friedlmeier, & Mayer, 2007). Matsumoto et al. (2009) assumed a distinct perspective in relation to emotional expressions. Contrary to a certain consensus, which agrees that when emotions are aroused the display of these emotions are either universal or culture-specific, these authors investigated the idea that an individual's emotional display in a given context can be both universal and culturally variable, as they change over time. Evidences from their study confirmed their hypotheses. Adults from individualistic and urban cultures expressed their emotions more than those from collectivistic and less urban culture, who had the tendency to mask their emotions. The results reported also indicated that these culturally influenced expressions occurred within a few seconds after initial, immediate, and universal emotional displays.

Cole and Tamang (1998) results support the idea of complexity and cultural specificities in relation to emotional expressions. They investigated mothers´ beliefs about appropriate

emotional behaviors for children in two different groups of Nepal (the Chhetri-Brahmin and the Tamang). Tamang mothers' group valued equality and harmony, based on Buddhist teachings. Their way of understanding the world and interpersonal relationships lead Tamang people to avoid strong emotions as anger. In turn, the Chhetri-Brahmin, who are part of the Nepalese Hindu population, are embedded in a social system ruled by caste. In this context, discipline and self-control are appreciated behaviors, and the expression of certain emotions is occasionally allowed. For this reason, people learn to soothe the expression of intense emotions.

Keller and Otto (2009) also analyzed the cultural determinants of emotion regulation and emotion expression in two different social groups (urban context in Berlim, and rural context in Cameroon) and found contrasting results. What they considered to be an urban Western group prototype emphasizes the expression of emotions in children, while in rural context in Cameroon it is desired that children be calm and do not express their emotions. Positive emotions stand out in the socialization goals and in interactions among urban middle-class in Berlin. In regards to negative emotion regulation, strategies adopted also differ completely. In one hand, German mothers talk with their babies, asking them about what is happening, in a quasi-dialog format, trying to find out the reason for crying, for example. On the other, Cameroonian mothers use shaming devices, requesting immediate compliance and restoring emotional harmony once the child complies.

An evolutionary perspective seems to be a fruitful approach to deal with emotions and their expressions. According to this view, we can consider the existence of some basic, innate and universal emotions and corresponding particular expressions universally expressed and recognized. Throughout our species' history certain emotional expressions had evolved in order to solve adaptive problems presented in the evolutionary environment. Although the biological basis of them as predetermined features of our species, it is clear the role of culture in the displaying of these emotions, as well as in the developmental process in which this displaying is based. The expression of emotions can be considered adaptive for men and other animals, and we consider this field of study as highly appropriate to discuss the interaction between biology and culture as a bi-directional trajectory.

6. Final considerations

This chapter presents some assumptions for a theoretical perspective to study human development. We argued in favor of a life cycle perspective from an evolutionary and social-cultural orientation, aiming at understanding ontogenesis with emphasis on epigenetic processes, which are based in our philogenetic history and occurre within specific social-cultural and historical contexts. The inseparable relationship between biology and culture was highlighted. This perspective should consider simultaneously universal and cultural aspects in development, focusing not only on traditional restricted groups of subjects in developmental studies, but considering groups from the *majority world*.

In order to illustrate the perspective proposed, we discussed recent research on specific aspects of development, such as parental care, attachment, and emotional expression. In all of them, it can be noted researchers' concern to take into account specific ecological and social-cultural contexts in which the studies had been developed. Evidences were presented and discussed avoiding inappropriate and hasty generalizations; universals were contrasted

with specificities. Such an approach seems more fruitful and consistent with the human development view here proposed. We believe this chapter may represent a starting point for students and professionals interested in human development.

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2

Inter-Functionality Between Mind, Biology and Culture: Some Epistemological Issues Concerning Human Psychological Development

Arnulf Kolstad
Norwegian University of Science and Technology (NTNU)
Norway

1. Introduction

The relationship between biology and culture, how it changes during the course of ontogenetic development, how it manifests itself and how it should be explained has been a persistent topic in developmental psychology. The conceptualization of the dialectical interactions between biology, mind and culture is crucial for psychological theorizing in general and for establishing a reasonable psychological epistemology. On the basis of recent research and empirical findings in cultural, cognitive and neurosciences, this chapter focuses on how higher psychological functions develop from a biological basis and how the mind and brain change owing to mental and physical activity. The higher psychological functions are humanly constructed when individuals participate in social interaction in a specific culture. The development of higher psychological functions as well as the development of the brain (its function and structure), cannot be explained without focusing on human activity and communication in a particular culture.

The relative weight assigned to nature versus nurture in different historical eras has varied. There are historical periods and recent traditions in which there was no place for any interaction, as if biology and culture were independent entities in terms of human development. The misleading character of such a dichotomous formulation has come to be recognized (Jahoda, 2002). The former sharp distinction between biology and culture is giving way to the recognition of their interrelationship, though its exact nature is still to be clarified and discussed. The inseparability of the two aspects and how we should understand human development as a result of their mutual interdependences is the topic considered in this chapter, which takes historical-cultural psychology as its point of departure.

Greenfield (2002) argues that there are different relations between cultural environment and biological nature in human development (i) Culture reinforces biology; (ii) Culture appropriates biology; (iii) Culture and biology are mutually adapted for survival; (iv) Culture selects from biology (The biological substrate provides the foundation for more than one capacity and the environment can reinforce one capacity more than another, for instance individualism more than interdependence); (v) Culture respects biology (Culture has sets of artifacts and practices that respect and stimulate sensitive times of cognitive and neural

development); (vi) Culture shapes and actualizes biological potential. These relations constitute ways in which culture and biology define and influence each other in development. These relationships make it clear that it is much too simplistic to think of biology on the inside and culture on the outside. The importance of the external culture depends on the internal biological capacity and the culture creep inside and establishes new human nature in brain and in mind.

A developmental perspective has often been lacking in theoretical discussions of biology and culture (Keller, Poortinga & Schölmerich, 2002). The relationships between biology, mind and culture can however only be explained if studied in a developmental and inter-functional, dialectic perspective as something changing and growing. Since this chapter focuses on the epistemology of developmental psychology it starts with a short presentation and a discussion of how humans have been described in recent cognitive psychology; characterized by a focus on humans as a machine and the brain as a computer.

2. The computer metaphor and the machine paradigm

According to popular metaphor, information processing in a human mind is analogous to the information processing that takes place in a computer. This *computer metaphor* has given rise to some basic – often implicit – assumptions (Bender & Beller, 2011; Block, 1995; Norenzayan & Heine, 2005) for instance that the brain's structure is fixed and hardwired. 'Localizationism', the idea that the brain is made up of parts, each of which performs a specific mental function is related to the computer metaphor (Doidge, 2007) but has proven to be misleading. According to Yaroshevsky, Vygotsky revised the traditional conceptions of the localization of psychological functions in the brain. "He rejected the view according to which each function (perception, speech, etc.) is represented by a definite area of the cortex. This view stemmed from the old notion of the independent manifestation of each separate function, of its production by the brain according to the same model as the functions of other body organs, and from the fact that a function is not subject to qualitative changes in its development" (Yaroshevsky, 1989: 257).

Descartes's idea of the brain as a complex machine culminated in our current idea of the brain as a computer and in localizationism. Mainstream psychology has relied heavily on these ideas (Block, 1995). The analogy between a computer and the human brain became fashionable with cognitive psychology in the 1980s and it was strengthened by neuroscience and brain research in the 1990s (the 'decade of the brain').

Psychological universals, or core mental attributes shared by humans everywhere, were also a fundamental postulate of psychology until recently. The 'psychic unity of humankind' holds that, irrespective of their cultural background, all humans have at their disposal the same psychological outfit. This position experienced a huge resurgence with the cognitive revolution which studied the 'inside' of humankind independent of external influence (Miller, 2003). This concentration on internal mental phenomena disregarded external factors with potential influence on psychological processes and up to the end of the twentieth century the potential of culture to affect cognitive processes was widely ignored (Bang et al., 2007; Henrich, Heine & Norenzayan, 2010). There were, however, also some studies on cultural effects in cognitive development by authors with a socio-cultural perspective, such as Barbara Rogoff and Michael Cole, among others.

There are of course similarities in psychological functions and behaviours among human beings independent of their cultural background. (See Norenzayan & Heine, 2005; and Poortinga & Soudjin, 2002 for a discussion of universalism and cultural relativism). Humans are strikingly similar in their genes and some universal behaviour arises from their biological/genetic similarity. Other psychological functions are universal because they are the result of innate, naturally selected, psychological tendencies that emerge everywhere in the same ontogenetic sequence (such as language acquisition; Pinker & Bloom, 1992), or they are cultural byproducts of naturally selected tendencies (such as religion, e.g., Atran & Norenzayan, 2004), or learned responses that serve a useful purpose everywhere, such as counting systems, calendars, writing, trading, and cognitions and behaviours associated with these inventions.

This often unstated assumption of human 'psychic unity' was strengthened by the influence of biology and the focus on instinctive or lower psychological functions also found in other species without language abilities and a complex culture. The biological heritage of psychology presupposes that psychological mechanisms are not only shared by (other) animals, they are also human universals (Norenzayan & Heine, 2005). This seems to justify the widespread habit of exploring psychological processes with selective samples, namely graduate students. If cognitive processes are universal, a North American student should be as good a subject for their exploration as anybody else. This assumption about universalism has however been challenged by recent cultural and cross-cultural research.

Cultural psychology first revealed that all higher psychological functions were influenced and actually created by cultural activity and communication. More recently it has been accepted that cultural tools and cultural practices have powerful influences on brain structures as well. Recurrent, active long-term engagement in a cultural setting can powerfully shape the mind and modify brain pathways (Chiao & Ambady, 2007; Chiao et al., 2010; Fiske, 2009; Han & Northoff, 2008; Kitayama & Park, 2010; Park & Gutchess, 2006).

As human beings we develop from a biological organism into cultural people. We are permanently changing, influencing each other and ourselves. Qualities are transformed, reshaped and new patterns or configurations are created all the time, both in the mind and in the brain. Separate elements which intervene create new elements, functions and phenomena and they again influence each other. Old functions or elements, for instance biological instincts, are still part of a human being, but the elements have changed to another form, with another meaning and signification in the mind as well as in the brain. The machine paradigm and the computer metaphor therefore do not offer a relevant frame for understanding how and why humans develops, and it is a significant task for an understanding of human developmental psychology to clarify how biology, culture and mind interact in a dialectical, inter-functional manner.

3. The alternative – The development of mind and brain

Human development is both biological and psychological; one cannot take place without the other. The biological brain is part of human psychology, and if the mind changes and differs from one culture to another, the brain has to change and be different as well. The brain internalizes the impact from its environment within its parameters of innate and developmental constraints. That the mind and brain changes and depend on cultural signs

has been documented in numerous empirical studies since the year 2000. Some of these studies and results will be referred to in this chapter. However, the main aim is to discuss what the new knowledge means for the epistemology of (developmental) psychology. What kind of paradigm is suitable and can incorporate the empirical facts? The epistemological question is to answer on the basis of empirical data, how mind, brain and culture are related, and how the documented interaction, inter-functionality and development can be conceptualized, described and explained.

The machine/computer paradigm is based on Western philosophy and epistemology, emphasizing a simple, deterministic world, focusing on salient objects instead of dialectical relationships. In this Western epistemology there is also a prohibition against contradiction. There is no place for quantitative development to create qualitative changes for new inter-functionality by combining components. Contemporary human sciences have inherited the Western focus on analyzing isolated single elements or variables representing isolated elements. They are knitted together in an additive or interactional way by multivariate statistics and linear mathematics, and this represents a mechanistic way of constituting a human being, not a dialectical or 'organic' way. Humankind as a machine has been not only a metaphor, but a model. Gaining knowledge about complex living organisms by treating them and their context in this way gives distorted knowledge about real human beings and this epistemology has to be rejected.

3.1 Natural sciences as a model for psychology, the importance of the environment, and the principle of inter-functionality

To criticize the machine model and the computer metaphor as paradigm for human psychology does not imply that psychology should not be inspired by (recent) natural sciences. Psychology should not, however, focus on essentialism or universalism if it is to become 'real (natural) science', since most natural 'laws' are dependent on the environment. The structure and functions of the elements and how they relate to each other (their function) cannot be explained without taking the environment into consideration. The combination of Oxygen and Hydrogen has quite different structures (and functions) depending on temperature and pressure. The mixture of the two elements has different states, ice below zero degrees Celsius, water between zero and 100 degrees Celsius, and vapour when the temperature is above 100 degrees Celsius (depending also on the atmospheric pressure). This is an example of a natural phenomenon heavily dependent on the environment. The same is the case for most elements, their structure and functions. Carbon is *coal* with one molecular structure when established in one environment and *diamond* with a totally different structure if established under other environmental circumstances and in another inter-functionality. The same element acquires a unique structure and function owing to the impact of other elements and the environment. It also changes structure and function through time. The human mind and brain are no exceptions in this respect.

Water also illustrates another important fact in nature, that a combination of elements does not have the same properties or qualities as its components. By combining elements with specific functions, the new inter-functionality can become totally different from the functions of its components. This is an example of the inter-functional, dialectical principle of development: when two qualities combine there will not be a simple addition of their

qualities, but often a totally new functionality that cannot be found in their constituents. Water has other properties than the elements of oxygen and hydrogen. Oxygen is necessary for fire and hydrogen is combustible, whereas water is used to extinguish fire. H2O is an example of a new inter-functionality, with its structure and function also depending on the environment. Human nature also develops in the ontogenesis in this way, establishing a new inter-functionality by combining biological and cultural components, constantly changing structure and functionality owing to physical and mental activity in a specific culture. This is an alternative epistemology of psychological development and more generally a paradigm for understanding human beings and their development.

4. Phylogenetic and ontogenetic development

The phylogenetic development of humans followed the principle of natural evolution. During this evolution humans acquired the *possibility* of speech and thought owing to the increased size of the brain and the voice-tube. These two abilities, language and thought, were combined at a certain stage of development and the language ability combined with thinking initiated a new era for humans: the cultural era, where psychological functions were no longer dependent to the same degree on the lower instinctive reactions. Gradually consciousness developed so that the instinctive biological forces were set aside. The acquired abilities changed human's further development radically.

Evolutionary biologists have for many years wondered why *Homo sapiens* became a new species so different from its animal ancestors. Usually they have looked for anatomical or morphological characteristics, for instance the size of the brain, the functional benefits of bipedalism, or the hand with opposite thumb able to seize. The unique ability to use language and symbolic systems is rarely mentioned. Because of this the relationship between biological and cultural development has not been analysed.

Language and other cultural tools are however a major contribution to human development. No species can accumulate progress across generations as smartly as humans owing, amongst other things, to the invention of written language. We can pass our experiences and transmit information and innovations across time and place to the future generations in a unique way. The *Neanderthals*, in many ways similar to *Homo sapiens* from a biological point of view, did not develop in the same way. They lacked the voice-tube and could not develop spoken language as did *Homo sapiens*. The voice-tube represented an enormous enhancement in flexibility concerning production of sounds and the improvement of communication and was responsible for human beings and the higher psychological functions as we know them today.

What had been a natural evolution of *Homo sapiens* became a cultural evolution for every individual. Human culture influences every individual's psychology and biology (especially the brain), and culture creates higher psychological functions, i.e. human perception, cognition, memory, motivation, emotions etc., all the functions with which psychologists deal.

4.1 Culture

Everybody is born into a specific culture that *cultivates* (from the Latin grow, cultivate) every human being. Culture is a term that has been given many meanings. In 1952, Alfred Kroeber

and Clyde Kluckhohn presented in their article '*Culture: A Critical Review of Concepts and Definitions*' more than 150 definitions and the number has increased since then. There is a general consensus that culture is organized by ideas (Kroeber & Kluckhohn, 1952), either in terms of explicitly shared knowledge, beliefs and values or by implicit or hidden assumptions inscribed in daily practices and institutionalized in routines, conventions, and societal norms (D`Andrade, 1995; Kitayama & Park, 2010; Shweder, 1991).

One might define culture as the shared knowledge, values, norms, morals, beliefs, and practices among a group of people living in geographical proximity who share a history, a language, and cultural identification (Atran et al., Ross, 2005). A more recent definition of culture introduced by social anthropologists is a '*body of background traits that are automatically imprinted and expressed in every individual of a certain culture*' (Vogeley & Roepstorff, 2009).

5. Cultural psychology: Culture makes us different

Many studies show that psychological functions or dimensions previously thought to be universal actually vary widely with culture (Cohen, 2001). Cross-cultural and cultural psychology have examined differences in psychological functions and provided accumulating evidence for the diversity of human cognition and behaviour across cultures, including perceptual processing, attention, attribution, motivation, language, number representation and mental calculation. What (and how) we perceive, think and feel actually depend on the culture in which we socialize. It also seeps much deeper into the structures of the mind than previously thought, sometimes bypassing the conscious mind altogether (Cohen, 1997).

From cultural and cross-cultural psychology we know that there are subtle differences in how people process information (Park & Huang, 2010). According to Nisbett and colleagues (2001), Westerners have a tendency to process central objects and organize information via rules and categories. In contrast, East Asians tend to view themselves as part of a larger whole, which results in holistic information-processing in which object and contextual information are jointly encoded.

The cultural dimension of individualism–collectivism has been shown reliably to affect a wide variety of mental processes at a behavioural level, including self-concept, motivation, perception, emotion and cognition (Markus & Kitayama, 1991; Triandis, 1995). Individualism refers to when individuals construe themselves as separate from and independent of each other, whereas collectivism refers to when individuals construe themselves as highly interconnected and defined by their relations and social context. Western cultures place more value on independence and individuality than do Eastern cultures, resulting in an attentional bias toward individual objects in an analytical, context-free manner and with less regard for relationships between items. In contrast, East Asian cultures emphasize interdependent relationships and monitoring of context, relationships and backgrounds (Chua et al., 2005; Nisbett & Miyamoto, 2005), resulting in an attentional bias toward contextual, relational processing of information (Nisbett, 2003; Nisbett & Masuda, 2003; Nisbett et al., 2001). The differences between individualistic and collectivistic cultures, originally studied by Hofstede (1980), are sometimes presented as a dichotomy. Most cultures and therefore also individuals, however, employ a unique blend of

independent and interdependent self-appraisal, which represent a composite mix of the individualistic and collective elements in each culture (Kolstad & Horpestad, 2009).

The human brain is not designed for objective registration. The experience of a sense impression depends on the context, former experiences and expectations. The same sense impression can be explained in different ways, at different times, in different cultures and from person to person. That happens for instance when we are explaining behaviour. The 'fundamental attribution error', the tendency to explain others' behaviour as arising from dispositions (personality) while neglecting situational causality, is more pronounced for Americans than for members of other cultures. South and East Asians, for instance, give more weight to situational forces in explaining the causes of people's actions (Nisbett, 2003).

Cultural experience can exert its effects from early infancy, perhaps even in the womb, as is the case for discriminating speech sounds (Polka & Werker, 1994), and throughout adulthood. Many innate tendencies undergo maturational development and may not emerge at all until later when the child's mind is already fully immersed in and dependent on a cultural environment.

The two decades since the 1990s have witnessed an explosion of research on cultural psychology and exploring cognitive diversity between cultures has become one of the hot topics in the field (Cohen, 2001; Gentner, 2010; Lloyd, 2007). Norenzayan & Heine (2005) have reviewed evidence of cultural influence on the nature of basic psychological processes. They cite the following studies indicating that some phenomena are less evident or appear in significantly divergent forms in other cultures. They include, from cognitive psychology, memory for and categorization of focal colours (Roberson, Davidoff, Davies, & Shapiro, 2004; Roberson, Davies, & Davidoff, 2000), spatial reasoning (Levinson, 1996), certain aspects of category-based inductive reasoning (Bailenson, Shum, Atran, Medin, & Coley, 2002; Medin & Atran, 2004), some perceptual illusions (e.g., Segall, Campbell, & Herskovits, 1963), perceptual habits (e.g., Masuda & Nisbett, 2001), habitual strategies for reasoning and categorization (e.g., Nisbett, Peng, Choi, & Norenzayan, 2001; Norenzayan, in press), the relation between thinking and speaking (e.g., Kim, 2002), and certain aspects of numerical reasoning (Gordon, 2004; K. F. Miller & Paredes, 1996); from judgment and decision making, preferred decisions in the ultimatum game (e.g., Henrich et al., in press) and risk preferences in decision making (Hsee & Weber, 1999); from social and personality psychology, independent self-concepts (e.g., Markus & Kitayama, 1991), the similarity-attraction effect (e.g., Heine & Renshaw, 2002), motivations for uniqueness (e.g., Kim & Markus, 1999), approach–avoidance motivations (e.g., Elliot, Chirkov, Kim, & Sheldon, 2001), the fundamental attribution error (e.g., Choi & Nisbett, 1998; J. G. Miller, 1984; Morris & Peng, 1994; Norenzayan & Nisbett, 2000), self-enhancing motivations (e.g., Heine, Lehman, Markus, & Kitayama, 1999), predilections for violence in response to insults (e.g., Nisbett & Cohen, 1996), high subjective well-being and positive affect (e.g., Diener, Diener, & Diener, 1995; Kitayama, Markus, & Kurokawa, 2000), feelings of control (e.g., Morling, Kitayama, & Miyamoto, 2002), communication styles (e.g., Sanchez-Burks et al., 2003), consistent selfviews (e.g., Suh, 2002), and emotion (e.g., Elfenbein & Ambady, 2002; Mesquita, 2001); from clinical psychology, the prevalence of major depression (Weissman et al., 1996), depression as centered on negative mood (e.g., Kleinman, 1982; Ryder, 2004), social anxiety (Okazaki, 1997), the prevalence of eating disorders such as anorexia nervosa and bulimia (e.g., Lee, 1995), and a number of other indigenous syndromes that have not yet received

much attention in the West (e.g., *agonias* among Azoreans, S. James, 2002; *ataque de nervios* among Latino populations, Liebowitz, Salma´n, Jusino, & Garfinkel, 1994; *hikikomori* among Japanese, Masataka, 2002; and *whakama* among the Maori, Sachdev, 1990); and from developmental psychology, the noun bias in language learning (Tardif, 1996), moral reasoning (e.g., A. B. Cohen & Rozin, 2001; J. G. Miller & Bersoff, 1992; Shweder, Much, Mahapatra, & Park, 1997), the prevalence of different attachment styles (e.g., Grossmann, Grossmann, Spangler, Suess, & Unzer, 1985), and the tumult and violence associated with adolescence, Schlegel & Barry, 1991).

Conclusive evidence for deep cultural impacts not only on cognition and psychological functions (mind), but on the very architecture of the brain is provided by cultural neuroscience (Ambady & Bharucha, 2009; Kitayama & Uskul, 2011). Cultural neuroscience increasingly provides evidence for the assumption that the brain is altered by learning and experience, organized by culture: 'The important message is that social interactions among humans shape neural connections, i.e. the fine-tuning of the brain… these interactions occur at a variety of neurophysiological and behavioural levels and are domain specific' (Keller, 2002: 216).

To the extent that sociocultural practices diverge, so will the psychological functions (Cole, 1996; Vygotsky, 1978), leading to neural specialization of culturally acquired abilities (Polk et al., 2002). How this develops in humans is described below.

6. The development of the brain (its plasticity)

The human brain adapts to what the senses and the mind acquire during socialization in a specific culture. This capacity is known as 'neuroplasticity'. Plasticity is the capacity a substance has to change and to preserve the tracks of an alteration. The brain can change owing to all kinds of influence and it keeps track of the alterations if the stimuli causing them are sufficiently strong or they are repeated enough times. The brain's structure changes according to its use and the impact from the environment. This change may take the form of the growth of new neurons, the creation of new networks and structures, or change within network structures.

This special characteristic allows the brain's estimated 100 billion nerve cells, also called neurons (aka 'grey matter'), to constantly lay down new pathways for neural communication and to rearrange existing ones and adapt to the experiences of the mind. Depending on which tasks are pursued and practised, very different patterns of neural activities are likely to be induced. These neural activities will eventually be over-learned, thus, becoming well connected and automatic. In other words, brain pathways will be modified and neural activities will be culturally patterned as a result (Kitayama & Park, 2010).

Neuroplasticity is not a trait found in a single brain structure, nor does it consist of just one simple type of physical or chemical event. Plasticity works throughout the brain in the normal processes of learning and adaptation. All parts of the brain change, develop and increase its capacity (Doidge, 2007). Production of new connections between neurons in many part of the brain occurs not only in the first few years of life, but also later in life as well. Neurogenesis can continue virtually throughout life in some areas of the brain (Kitayama & Park, 2010).

There is a wealth of evidence that experiences sculpt both brain and behaviour. Recent work in cognitive neuroscience has provided clear evidence that sustained experience changes neural structures. For example, London taxi drivers who engage in sustained route finding show more grey matter in the posterior hippocampus, with the magnitude of the effect increasing with experience, suggesting experience is the causal mechanism (Maguire et al., 2000). Canadian postal workers spend thousands of hours sorting postal codes by letters and numbers jointly, and this experience changes the categorical representation of these two symbolic systems into a single more unitary system (Polk & Farah, 1998). Sustained practice in learning to juggle increases the volume of cortical tissue in the bilateral mid-temporal area and left posterior intraparietal sulcus (Draganski et al., 2004); the effect also generalizes to older adults (Boyke et al., 2008).

In response to a new experience or novel information, neuroplasticity allows either an alteration to the structure of existing connections between neurons, or forms brand-new connections between neurons; the latter leads to an increase in overall synaptic density, whereas the former merely makes existing pathways more efficient or suitable. In either case, the brain is remoulded to take in these new data. The new information or sensory experience is cemented into what seems to be the most useful and efficient location within the massive neurocommunication network. Further repetition of the same information or experience may lead to more modifications in the connections that house it, or an increase in the number of connections that can access it – again, as a result of the amazing plasticity of our brains. New research suggests that, beyond modifying pathways and forming new ones between existing neurons, the human brain is even able to generate entirely new brain *cells* in some parts of the brain.

How it happens that the brain changes and develops its capacity by being used is not the topic of this chapter. It is however much more intricate than establishing new connections between neurons and increase 'grey matter'. There are electrochemical connections which use electrolytic neurotransmitters more complicated than our simple models and metaphors can describe and explain. We know only a few of the chemical neurotransmitters and do not know in detail how the brain functions and changes its function, working together and interdependently with the mind and supporting the higher psychological functions.

A simple way of illustrating how the brain develops is to say that the connection between the neurons (the synapses) is a sort of road transporting information from one cell to another by means of the electrical current in chemicals. At birth there are certain highways established by the genetic outfit and experiences in the womb. The genes certainly play a role in establishing the brain's ability to develop and function at birth; the environment and culture become however more and more influential in how the brain and the mind develop. Every day a newborn's brain is flooded with new information from the environment, grasped by the baby's sense organs. The neurons are responsible for sending that input to the part of the brain best equipped to handle it. This requires that each neuron 'knows' the proper pathways. To make this mental roadmap work, each neuron develops an axon to send information to other brain cells via electrical impulses, and also develops many connections to other neurons so that it can receive information from them. The genes have, at birth, laid down the basic directions for neurons to follow and built major 'highways' between the basic areas of the brain. Environmental influence plays a key role in forging a denser and more complex network of interconnections. Short-term exposure to an enriched

environment leads to a striking increase in new synapses (Kempermann et al., 2002). These smaller avenues and side-roads make the transfer of information between neurons more efficient and rich situation-specific detail. This is clearly evidenced by the rapid increase in synaptic density that can be seen in a normally developing human. At birth, each neuron has approximately 2,500 synapses or connections. By the age of two or three, sensory stimulation and environmental experience have taken full advantage of the brain's plasticity; each neuron now boasts around 15,000 synapses (Gopnick et al., 1999). This number will have declined somewhat by the time we enter adulthood, as many of the more ineffective or rarely used connections – formed during the early years, when neuroplasticity is at its peak — are done away with.

The brain plasticity is a well-documented fact, and in the following I present how culture changes the brain's structure and functions.

7. Cultural neuroscience

Cultural neuroscience examines the influence of culture on brain and behaviour and how cultural values, practices and beliefs shape brain function, develops brain structure, and affects the neural architecture (Chiao & Ambady, 2007; Chiao, et al., 2010; Gutchess, et al., 2006). Cultural neuroscience represents a novel empirical approach to the study of interactions between culture and biology by integrating theory and methods from cultural psychology (Kitayama & Cohen, 2007) and neuroscience (Chiao, et al., 2010; Fiske, 2009; Gazzaniga, Ivry & Mangun, 2002; Han & Northoff, 2008).

Cultural psychology and neuroscience might seem to inhabit opposite ends of the scientific spectrum (Ames & Fiske, 2010). They have evolved as separate disciplines but, in reality, cultural values, beliefs, and practices must be important to brain functioning. Culture is, after all, stored in people's brains. The human brain has uniquely evolved to acquire basic cultural capacities, such as language (Chomsky, 1965) and morality (Mikhail, 2007). On the other hand, without the requisite neurobiological capabilities, culture could not function.

Cultural neuroscience is motivated by an intriguing question about human nature: how do cultural traits (e.g. values, beliefs, practices) shape neurobiology (e.g. genetic and neural processes) and behaviour or, more generally, how do we describe and explain the mutual construction of brain, mind and culture, especially from a developmental perspective?

An arsenal of techniques for mapping neural processes to psychological processes has been adopted (Chiao, et al., 2010). Ten years ago, functional magnetic resonance imaging (fMRI) studies were published for the first time in order to investigate the impact of culture on the brain (Phelps et al., 2000). Since then the number of publications using this procedure has increased tremendously. The results have shown how cultural traits may shape the emergence of neurobiological and psychological processes and facilitate complex social experience and higher psychological functions, such as perception and cognition (Chiao et al., 2010).

In a functional magnetic resonance imaging (fMRI) study (Gutchess et al., 2006), Chinese and American participants judged various pictures of objects, backgrounds, and their combinations. Consistent with prior behavioural studies suggesting greater object-focused processing among Westerners, American participants (compared with Chinese participants)

demonstrated stronger and more distributed neural activations during object processing. Specifically, Americans more often recruited the middle temporal gyrus (implicated in semantic knowledge retrieval during object perception; (Martin et al., 1996), right superior temporal/supramarginal gyrus (important for the encoding of spatial information; Aguirre & D'Esposito, 1997; Ungerleider, 1995), and superior parietal lobule (which tracks successful encoding of object locations) (Sommer et al., 2005).

It is reasonable to posit that sustained exposure to a set of cultural experience and behavioural practices will affect neural structure and function (Park & Huang, 2010). The collectivistic and individualistic biases of East Asian and Western cultures, respectively, discussed earlier, also affect neural structure and activity (Chiao et al., 2008; Park & Huang, 2010). People who endorse individualistic cultural values show greater medial prefrontal cortex (MPFC) activation to general self-descriptions, whereas people who endorse collectivistic cultural values show greater MPFC activation to contextual self-descriptions. The results reveal two kinds of neural representations of self (e.g. a general self and a contextual self) within MPFC and demonstrate how cultural values of individualism and collectivism shape these neural representations (Chiao, et al., 2009).

Differences in cognitive processes related to processing information holistically (East Asians) or analytically (Westerners) are also accompanied by differences in brain structure. Cultural variation in preference for social hierarchy also leads to increased engagement of specific brain regions (Cheon, et al., 2011). Different languages create different brains. The brain activity of native English speakers is different from that of native Chinese speakers (Tang et al., 2006). The findings could be attributed to exposures to different visual patterns owing to the visual-spatial nature of the Chinese language and activation of language areas for English speakers.

7.1 Self-representations in the brains

People from different cultures may have divergent perceptions of the self. People from Western cultures tend to value uniqueness and view the self as independent of others, whereas people from South East Asian cultures tend to value social harmony and adherence to group norms and view the self as interconnected and interdependent with others. One of the first social-cultural topics to be explored in neuroscience was how people represent the self (Craik et al., 1999). Across a wide range of studies, including both Western (Kelley et al., 2002) and Eastern (Zhang et al., 2006) participants, an area of the ventral mPFC/anterior cingulated cortex (ACC) appeared to be activated more for thinking about the self than about other people. Given the cultural differences in self-other construal, however, particular differences in Western independent views of the self as distinct from others and Eastern interdependent views of the self as fundamentally related to others (Markus & Kitayama, 1991) also emerge at the level of the brain. This finding (Zhu et al., 2007) supports previous theoretical assertions that Easterners view close others (and their relationships with those close others) as part of the self, whereas Westerners tend to conceive of the self as an independent entity. Representation of self shapes neural activations, making a compelling case for cultural values determining neural function (Kitayama & Park, 2010; Park & Huang, 2010).

In the domain of perception, several studies suggest that Westerners tend to focus on objects whereas East Asians tend to focus on contextual and background information (Hedden et

al., 2008). A similar pattern showing cultural effects on perception and neural activation was found by Gutchess et al. (2006).

Given the evidence described above showing that experiences affect the volume of neural structures and category organization, it is reasonable to posit that sustained exposure to a set of cultural experiences and behavioural practices will affect neural structure and function (Park & Huang, 2010). The discovery of an alteration in the brain's macroscopic structure contradicts the traditionally held view that cortical plasticity is associated with functional rather than anatomical changes (Draganski et al., 2004). Culture's influences on the brain result from participation and engagement in culture's conventions, routines, and socially shared scripts for action (Goh & Park, 2009; Han & Northoff, 2008; Nisbett & Masuda, 2003; Nisbett et al., 2001; Park & Huang, 2010). There is conclusive evidence for deep cultural impacts not only on cognition but on the very architecture of the brain, provided by cultural neuroscience (Ambady & Bharucha, 2009; Kitayama & Uskul, 2011).

All examples of how culture affects the brain are related to higher psychological functions, not lower. The higher functions are developed by experience and activity in a culture. The brain growth increases its capacity for higher psychological functions.

8. Cultural-historical psychology: How culture overrules biology in humans

The cultural-historical tradition in social and developmental psychology was founded by the Russian psychologist Lev Vygotsky in the 1920s. He and his Russian colleague Alexander Luria were impressed, and at the same time dissatisfied, with the 'psychological' research on classical conditioning by their fellow countryman Ivan Pavlov. Although Pavlov's scientific methods were appreciated, Pavlov and other associationists and behaviourists were criticized for not studying the most important subject in psychology: the human mind and consciousness. Pavlov's work was, quite literally, 'thoughtless'. The ancient picture of a human as a being moulded out of soul and body still coloured scientific thought. The alternative solution at which radical reflexologists and behaviourists arrived was simple: they wanted to put an end to consciousness by finding bodily equivalents for it in the organism's reaction to external stimuli. It was assumed that psychology would be able to establish its laws by studying the behaviour of animals: white rats, cats, dogs, monkeys, and so on. Psychology was 'zoologised'. To reveal that animals could be conditioned to learn through associations did not expose anything about the specific and most interesting ability in humans; the capability to think, to use a language, to behave volitionally and to adhere to cultural norms and values. The development of the higher psychological functions acquired in a cultural setting had to be the main topic for understanding human psychology: 'Pavlov's theory stopped short of the higher forms of behaviour, the forms inherent in man the personality, not just man the organism' (Yaroshevsky, 1989: 216).

From recent empirical research in cultural psychology and cultural neuroscience we can conclude that all higher psychological phenomena, including perception, cognition, emotion, memory, self-appraisal, motivation, etc. have a cultural character. They are humanly constructed as individuals participate in social interaction and employ cultural/psychological tools. Brains and mind are shaped by experiences in the culture in which humans develop and live. Culture becomes part of each person's nature, stored in their mind and brain. The (higher) psychological functions are socio-cultural and historical

in origin. The structure of psychological activity – not just content but also the general forms – changes in the course of historical and ontogenetic development. From a phylogenetic point of view '…man differs from the adaption and development of animals because the process of mental development in man is part of the total process of the historical development of humanity' (Vygotsky, 1997: 39).

Humans are at the same time biological organisms from nature, however, and Vygotsky saw the contradictions between the natural and the cultural as the 'locomotive' of the history of the child; he wanted to clarify the dialectics of that history and human development in general. Ontogenetic development can only be understood as the history of behaviour, represented by the development of the higher psychological functions. It was from this position that Vygotsky embarked on the study of ontogenesis. According to Miller (2002: 142), culture is a 'symbolic medium for human development and participation in this medium is necessary for the emergence of all higher-order psychological processes'.

8.1 Evolution made us for culture

These higher-order functions became a possibility since natural evolution made thinking and language appropriation possible, and because we established human cultures which developed higher psychological functions in each individual whatever culture they were born into (Fiske et al., 1998). When human beings participate in social interactions and employ tools, for instance language and other cultural signs, they develop, construct and create their higher psychological functions, ways of thinking, feeling, remembering, their sensation and perception. These functions are not natural or inborn processes in human adults as they are in animals and human neonates. 'Most basic is the fact that man not only develops (naturally); he also constructs himself' (Vygotsky, 1989: 65). Therefore there are qualitative differences between the psyche of humans and that of animals. Unlike animals the key to human's psychological functions is sociogenesis (the transformation of social relations, through interiorization, into the individual's psychological functions).

Understanding how biology and culture interact, how this transformation of elementary, biological functions progresses into higher cultural functions, and especially how the relationships between mind, brain and culture develop is an epistemological task focused on the following.

8.2 'Second nature'

The young child is a pre-cultural biological organism, which becomes transformed by a series of cultural devices such as language, tools and artefacts into a cultural being and thereby acquires the higher psychological functions. In fact the acculturation starts even earlier since culture is present at conception and also in mothers' practices, such as her feeding and rest during pregnancy. As Michael Cole has said, the babies are born bathed in amniotic fluid and in culture. At the same time there is no clear dividing line between 'natural' and 'cultural', especially with regard to the brain. Cultural differences are persistent because our native culture is learned and fastened in our brains. It becomes 'second nature' seemingly as 'natural' as many of the instincts we were born with. We do not distinguish our 'second nature' from our 'original nature' since the neuroplastic brain, once rewired, develops a new second nature, every bit as biological as the original (Doidge,

2007). There is no hardwired 'nature' in the brain that last a lifetime. The distinction between nature and culture is not easy to draw on the psychological level either, partly because the cultural becomes natural in the brain's structure.

The tastes our culture creates – in foods, in type of family, in love, in work – often seem 'natural' and obvious, even though they may be acquired tastes. Nonverbal communication – how close we stand to other people, the rhythms and volume of our speech, how long we wait before interrupting conversation – all seem 'natural' to us, because the behaviours are deeply wired into the brain's 'new' nature. When we change cultures, however, we are shocked to learn that these customs are not natural at all but characterize a particular culture (Doidge, 2007).

8.3 Biology and the socio-cultural

Psychology involves and includes natural, biological processes, such as neuronal and hormonal activity, just as it involves breathing air. Just as breathing air is a precondition of psychology which plays no specific determining role in the form, content, mechanisms, and function of psychology, however, so other natural biological processes play no specific determining role either. Their role is analogous to that of breathing. Without breathing, hormones, and the brain, psychological activity would cease; however, with them it is only potentiated, not determined (Ratner, 2011).

The role of biology in psychology and behaviour changes from animals to humans. Biology, instincts and drives determine animal behaviour in natural environments; for human psychological functions and social behaviour biology changes to a potentiating, energizing function. As Ratner (2011: 50) claims 'This is only logical, and it is Darwinian, for we have seen that the fundamental principle of Darwinism is that organismic behaviour is a function of environment. Culture is a radically different environment from nature; therefore cultural behaviour and its mechanisms must be radically different from natural behavioural mechanisms of animals'. The different role played by biology is not a difference in degree between animals and humans, but in principle, as formulated by Vygotsky and Luria (1930/1993: 170): 'behaviour becomes social and cultural not only in its contents [i.e., what we think about] but also in its mechanisms, in its means…A huge inventory of psychological mechanisms -- skills, forms of behaviour, cultural signs and devices -- has evolved in the process of cultural development'.

Biology has lost its determining function in human behaviour. To live in a human constructed culture calls for socially constructed, designed, voluntary, changeable behaviour. Culture determines the form, content, and conditions of behaviour. In contrast, the form, content, and conditions of animal behaviour are determined by natural, biological elements. Elementary, natural mechanisms are antithetical to cultural-psychological mechanisms and features. Biological processes and lower, elementary psychological functions therefore have to recede into the background as a general potentiating substratum of behaviour (Ratner, 2011). The driving forces of biological evolution within the animal world lose their decisive importance as soon as we pass on to the historical development of man. New laws regulating the course of human history which cover the entire process of the material and mental development of human society now take their place (Vygotsky & Luria, 1930/1993). The biological and elementary functions have not disappeared but they have

changed their function and importance as they mingle with higher cultural functions. There is an inter-functionality between the organic maturation and cultural learning which characterize the merging and the development of a child into a culture. Cultural learning and the acquisition of cultural tools involve a fusion with the processes of organic maturation. The two contributions to development – the natural and the cultural – coincide and mingle with one another; they penetrate one another and essentially form a single line of sociobiological formation of the child as a cultural human being, developed from a biological being.

The psychology of humans is not something laid down inside humans by birth, but it is created by activity and communication in a culture. The human mind is therefore socially mediated, or as asserted by Vygotsky, 'Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and the inside the child (intra-psychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All higher functions originate as actual relationships between individuals' (Vygotsky, 1978: 57).

8.4 The lower and the higher psychological functions

Vygotsky distinguished between 'lower' or natural psychological functions and 'higher' or cultural functions. The lower functions are biological mechanisms, such as the blind reactions to stimuli that we see in all animals. They do not involve conscious experience. Over time, these lower functions are transformed, and are controlled by higher 'cultural' functions (Van der Veer & Valsiner, 1991, 1994). There are important distinctions between the lower or elementary functions and higher psychological functions. The latter develop from the former and at the same time change the lower ones to something different, absorbing them into new functions by the principle of developing inter-functionality. The elementary functions do not disappear but are changed (and usually reduced in importance) when combined with cultural components in the human mind and brain.

Higher mental functions are not simply a continuation of elementary functions and are not their mechanical combination but a qualitatively new formation that develops according to completely special laws and is subject to completely different patterns. They actually stimulate neuronal growth in particular directions and create their own biological mediations, restructuring the brain, becoming second nature (Vygotsky, 1986; Wertsch, 2008). This position does not, as we have seen, leave out biological factors or disregard biological influences. Quite the contrary; according to cultural-historical psychology, biological phenomena provide the framework for mental phenomena but do not directly determine them. This leaves psychological activity as something to be built up from, rather than reduced to, a biological substratum. To be human means to have surpassed a level of functioning that the biological traits would otherwise dictate (Van der Veer & van Uzendoorn, 1985). The genetic or instinctive driving forces are overruled by what is acquired during socialization in a particular culture. The number of human activities under biological control is greatly reduced in comparison with animals. Conscious behaviour is only possible if the elementary lower functions are set aside from their original function. Psychological phenomena, including perception, cognition, emotion, memory, motivation, personality, and identity are humanly constructed when individuals participate in social interaction. The most peculiar aspect of humans compared with other living species is that

humans are created by a culture that they have created. Their higher psychological functions are acquired in a human culture using symbols and signs (language).

The elementary natural processes operate in different ways from cultural conscious processes and therefore the former cannot govern the latter. They do not even serve as the basis of the latter. The lower or elementary natural processes are actually inimical to cultural conscious processes since they are automatic, mechanical, involuntary, physical processes; which directly impel non-volitional, unconscious behaviour. The division of the presocial, lower (natural) functions from the higher (cultural) ones illustrates the difference between animal and human and defines the human psyche as a special system for conscious, volitional regulation of the behaviour of the human organism whose individual development (unlike the organism of the animal) integrates the biological and the socio-cultural.

Natural processes operate in hummingbirds, for example. to automatically impel them to fly toward red-coloured flowers; or they impel male dogs involuntarily and mechanically to mount and mate with a female dog that emits a particular scent during the fertile period. Hummingbirds and dogs do not think about what they are doing, they cannot control it, they cannot plan it or imagine it, or remember (relive) it in specific detail; they do not appreciate the object of their behaviour, as a human male appreciates his sexual partner or appreciates a beautiful sunset or painting. This is why elementary natural processes cannot determine psychology in the same way that they determine behaviour of birds and dogs (Ratner, 2011).

The lower psychological functions, those automatic, instinctive kinds of behaviour are automatic and not controlled by consciousness. To be a human, however, means to reduce the automatic, instinctive behaviour and become a conscious being, able to decide, choose, and think with language as a cultural and psychological tool. Humans' higher psychological functions, their language and thinking, have to be the core of human psychology. Scientific psychology cannot ignore the volitional and conscious mind. It has to be a significant topic in psychology.

'Freud, following Darwin, also divided the brain into 'lower' parts that we share with animals, and that process our brute animal instincts, and 'higher' parts that are uniquely human' (Doidge, 2007: 297). Freud believed that civilization rests on the partial inhibition of lower functions such as sexual and aggressive instincts. He also believed we could go too far in repressing our instincts, leading us to develop neuroses (Doidge, 2007).

The new developments in cultural psychology and cultural neuroscience and the technological advances that make mapping of brain cell activity and brain structure possible are extending interest in higher-order psychological functions. Cultural psychology is highlighting the role of cultural meanings and practices in completing the self and in effecting the form of basic psychological processes (Miller, 2002).

8.5 A social relation is translated into a psychological one

When human beings participate in social interactions they develop, construct and create their psychological substance, ways of thinking, feeling, remembering, their sensation and perception, etc. In this way culture becomes part of a person's nature. The socio-cultural

environment created by humans develops higher psychological functions. If, however, human psychology is socially and cultural determined, does this mean that the individual is reduced to an automaton that passively receives social influences and that psychological functions are simple projections of socio-cultural relations? Quite the contrary: 'The child begins to see the external world not simply with his eye as a perceiving and conducting apparatus - the child sees with all of his previous experience...' (Vygotsky & Luria, 1930/1993: 148). The higher psychological functions, based on psychological or cultural tools, are created by the individual in cultural/social interaction and communication. They are acquired in an active and creative manner in the historical and cultural context and are unique to every individual, depending alike on genetic features, lower psychological functions and socio-cultural experience.

How does this transformation happen? How does reflex attention become volitional? How does mechanical memory become logical, conditioned action conscious and volitional? How is the socio-cultural experience translated into something psychological inside every individual? The principle of interiorization or transference of the external into the internal has to be explained in more detail. The question is how the psychological function, originally a social function, is mediated by a cultural sign and becomes intra-psychical (Yaroshevsky, 1989).

Vygotsky often quotes Marx's dictum: "Peter only establishes his own identity as a man by first comparing himself with Paul as a being of like kind" (Marx, 1978: 61). The real story of the individual in the story about Peter and Paul …. lies in transferring a social relation (a relation between men) into a psychological one (within the individual). Personality as a reality does not exist "in itself" from the beginning. Personality emerges only through the individual "revealing to others his own in himself". Accordingly, personality development, which can be called cultural development of the individual psyche, emerges from collective life, and from the processes taking place there. The basis of these processes is interaction between people.

The development of mind and other psychological functions involves the overcoming of two forms of reductionism: biological (which sees development as the maturing of an organism) and sociological (which reduces development to the 'appropriation' by the child of socio-cultural characteristics. As regards sociological reductionism, it completely ignores the proper inner logic of the transformations which a child's inner life goes through with the changes of the 'seasons of life' (Yaroshevsky, 1989: 277).

8.6 Signs, words and language

Cultural signs as a psychological tool are important elements in the stimulus-reaction connection for humans. This tool has become the principal instrument for transforming elementary functions into higher ones. Originally, though, it was used in communication, direct and open communication between individuals. Higher psychological functions are therefore just as cultural as they are social in origin. Each higher psychological function, appears twice: first in communication between humans, and only then does it 'move inside' (is interiorized), becoming the subject's property and inalienable from him/her.

Vygotsky said that the greatest drama of development was played out in the very first words of a child – the conflict between the natural and the socio-historical. Penetration of

the plot of that drama and its motive forces led Vygotsky to his principal theory – the theory of the development of the higher psychological functions (Yaroshevsky, 1989). Language is the most important sign. The hallmark of humans is our capacity to learn and use psychological tools like language.

From the very beginning a child is led along the path of psychological development by adults. Communication serves as a necessary condition for each new turn of a child's thought. Communication assumes understanding, and the instrument of understanding is the word. The word's 'adult' meaning, however, cannot be poured into the head of a little child together with the sign of the language; the words meaning will change during development and new words or concepts develop our understanding and enter into new connections, and our knowledge and understanding increase with the relation the word enters into.

The tools for the mind, for example language, are also changing the brain's function and structure. The tools are situated in and belong to the culture, and they are internalized and become psychological tools during socialization. People in different cultures, with different tools such as different languages also have different higher psychological functions, and different perceptions, motivations, emotions, and cognitions, in short everything that psychologists are interested in.

The architecture of the neurosystem changes fundamentally with the inclusion of symbols and signs in the mental organization. The brain has to follow this development of the mind using more words and concepts, acquired in communications with others, and has to change its structure and function to represent the communication experiences and the mind. When we learn to read and write our functional cognitive architecture changes and mental functions are reorganized.

Language is not created by the subject. It exists independently of it. The task with which the subject is concerned is the use of a ready-made sign system (not one she/he creates on his own) in communication, cognition or action in the surrounding world. We often hear that 'language is a tool of thought'. This is a familiar expression among psychologists but language is much more than a tool for thought. The word also has a volitional function. Humans' locomototive apparatus is subordinate to it. The word has power over the real actions of humans' bodily structure and their psychological functions (Yaroshevsky, 1989).

8.7 Final considerations: Hegel's dialectic and inter-functionality: A systemic approach

As described above the inter-functionalities of the lower and higher psychological functions are related in a dialectical way. With the appearance of psychological functions of a higher order, the lower functions are transformed, becoming elements of a new fusion and being retained in a sublated form. The sublation can be conceived in Hegelian fashion as a dialectical transformation. 'Lower' instincts and higher cognitive cerebral parts of the brain and the mind create a new inter-functionality and are the source of development of the 'lower' instincts.

Another important aspect of the higher psychological functions is their systemic character. They do not function separately but form an articulate whole. Each of them can therefore be

scientifically explained only if the dynamics of its interrelations with the other functions are considered. On the other hand, psychological functions are not a separate homogeneous form of consciousness, such as perception, thinking, imagination or will. The study of the psyche must therefore be focused on the system of functions as a whole rather than on one separate function tied to a separate centre in the brain. The psyche is a functional system that should be grasped in its development, which acquires a socio-historical character in the transition from the animal organism to the human one.

The study of how biologically determined elementary functions in a child operating with such a tool as language are transformed into higher functions is a central topic in developmental psychology: it can explain how a biological organism becomes conscious and volitional. Cultural historical psychology represents a dialectical and inter-functional understanding of human development. It focuses on how humans' higher psychological functions are created and how they relate to lower functions (biology) and the cultural context. Why these interrelations are crucial for an understanding of human development and the analysis of developmental processes allows us to understand the interaction between biological predispositions and environmental information with respect to the initiation of culturally informed developmental pathways (Keller, 2002). The biological heritage and the cultural present are components of the same developmental processes.

In mainstream psychology there is no place for dialectical thinking, inter-functionality and contradictions. The deterministic, non-dialectical way of thinking is a typical Western way of reasoning, emphasizing a simple, deterministic world, and focusing on salient objects instead of dialectical relationships and the whole or totality. In Western epistemology there is a prohibition against contradictions. There is no place for quantitative development to create qualitative changes and new inter-functionality by combining components. Contemporary psychology has inherited the Western focus on analyzing isolated single elements or variables representing isolated elements. They are knitted together in a mechanical, additive or interactional way by multivariate statistics and linear mathematics. This represents a mechanistic way of constituting a human being, not a dialectical or systemic way. Humans have to be understood by a systemic, dialectical paradigm more than a mechanical and analytic epistemology.

The cultural-historical approach to psychology is fundamentally *systemic*. That means a simultaneous search for (i) elements of a structure, (ii) relationships and emerging wholes, (iii) development. The cultural-historical approach seeks for unified understanding of the human culturally shaped mind as a semiotically mediated functional system. Different levels of explanation must be dealt with in explicit complementary relationships and the unified understanding at each level of explanation has to be related to the systemic properties of a whole. No analytic study can make sense unless conducted with an understanding of the place each element has in a whole. The cultural-historical approach seeks understanding of the mind from biological, psychological and socio-cultural perspective simultaneously.

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3

Development of Bipedal and Quadrupedal Locomotion in Humans from a Dynamical Systems Perspective

Üner Tan
(Honorary Member of the Turkish Academy of Sciences, Ankara, Turkey)
Çukurova University, Medical School, Department of Physiology, Adana
Turkey

1. Introduction

Locomotion is the movement of an organism from one place to another, often by the action of appendages such as flagella, limbs, or wings. In some animals, such as fish, locomotion results from a wavelike series of muscle contractions (The American Heritage® Science Dictionary, 2005). Walking is the act of traveling by foot; gait is the manner of walking; running is the act of traveling on foot at a fast pace; crawling is a slow mode of hand-knee or hand-foot locomotion. Quadrupedal locomotion, walking on all four extremities, is the most remarkable trait of the quadruped animals, and has been elegantly elaborated by dynamic selection processes over millions of years. Non-primate mammals usually utilize lateral-sequence quadrupedalism, in which the hindlimb footfall leads the ipsilateral forelimb, whereas the non-human primates utilize a diagonal-sequence quadrupedalism, in which the hindlimb moves with the contralateral forelimb in a diagonal couplet. The neural control for the quadrupedal and bipedal locomotor processes in monkeys may also be applicable to human locomotion (Xiang, 2007).

2. Historical development

The first historical evidence of the gait analysis is from the time of Aristotle (384-322 BC), who presented the first written reference to gait analysis (Baker, 2007). However, he was not able to test his hypothesis by experiment, and his observation-based ideas were later not supported by applying them to scientific experiments. Galileo Galilei (1564-1642) was the first to be able to test hypotheses by experiments, to prove any conjecture.

Giovanni Alfonso Borelli (1608-1679), one of the Galileo's pupils, first experimented to develop a gait analysis (Borelli, 1989). A rather detailed history of gait analysis was presented by Baker (2007).

The first known instance of human quadrupedalism was reported by the great English photographer Eadweard Muybridge (1830-1904), who created movement by displaying individual photographs in rapid succession (Muybridge, 1901). The child with a paralyzed leg due to infantile poliomyelitis was photographed and animated by Muybridge (1887,

1901). Despite the paralyzed leg, the child was able to move using diagonal-sequence quadrupedal locomotion (Fig. 1).

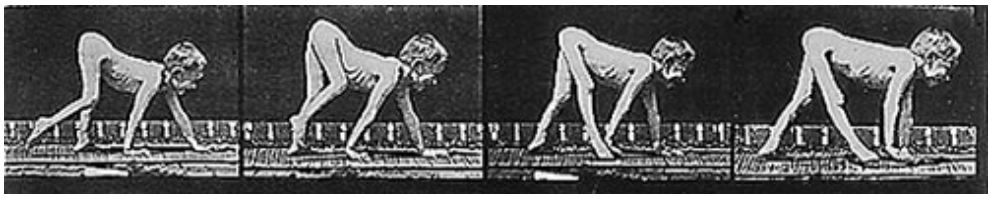

Fig. 1. Child walking on hands and feet, plate 539 from "Animal Locomotion" (Muybridge, 1887).

The first description of human quadrupedalism in adults was that of Childs (1917), a British traveler, during his trip along the historical Baghdad Road, through Havza (Greek: Hafsa) near Samsun (Greek: Samsounta), in the middle region of the Black Sea coast. The man, a beggar most probably belonging to a Greek family, had longer arms than legs, as judged from the slope of the hill, and from the report in Childs's book. He also probably belonged to a consanguineous family, since the Greek population lived in isolation in this region of the Black Sea coast, with many possible interfamilial marriages. Although he could not stand up without assistance, he was a man with rather strong arm and leg muscles, and could easily spring onto his donkey's back. This man is depicted in Fig. 2.

This case was the first adult quadruped man exhibiting Uner Tan Syndrome (UTS) with quadrupedalism, possible mild mental retardation, and dysarthric or no speech (see Tan, 2010a for a review). The arm to leg ratio (calculated from the picture) was rather high, 92%, similar to the arm: leg ratio of 90% in one case with UTS in the Adana 1 family (see Tan, 2006b, c).

Fig. 2. The man with habitual quadrupedal locomotion discovered in Northern Turkey by Childs in 1917 (see Childs, 1917, p. 27).

Children with habitual quadrupedal locomotion were first reported by Hrdlicka (1928): 41 children (59% males, 41% females). The children began to walk on all fours at the age when healthy children begin to crawl on hands and knees. Some of them were later able to stand and begin to walk bipedally, but others continued walking and running on all fours for a long time. Fig. 3 depicts native African children running around on all fours. Their quadrupedal locomotion seems to be their natural gait, with easy and fast running. Fig. 4 depicts children with diagonal-sequence quadrupedal locomotion (right) and moving down or up stairs on all fours (left) (Hrdlicka, 1931, pp. 29 and 109).

Fig. 3. Two native African children scooting around on all fours easily and so swiftly it was even difficult to take their pictures. From Hrdlicka (1931).

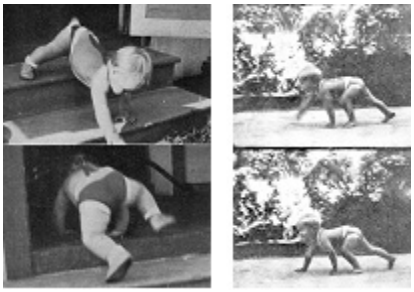

Fig. 4. Children with quadrupedal locomotion: left, a child moving down and up stairs on all fours; right, with diagonal-sequence quadrupedal locomotion (Hrdlicka, 1931).

Interestingly, not a single case with quadrupedalism was reported after the Childs' case (see Childs, 1917) until the discovery of the Turkish quadrupeds, almost 100 years later (Tan, 2005, 2006a). These individuals exhibited a never previously reported novel syndrome, referred to as Uner Tan syndrome (UTS), with the main symptoms of habitual locomotion on all fours, mental retardation, and impaired speech (Tan, 2005; Tan 2006a). Subsequently, nine more families with this syndrome have since been reported in Turkey since the discovery in 2005 (see Tan, 2010a for a review). The clinical and radiological characteristics of these cases are presented in Table 1. The syndrome has sparked a world-wide interest: see, for instance, Garber (2008), Ghika (2008), Caglayan (2008, Thesis), Akpinar (2009), Le Fanu (2009), Held (2009), Kolb (2009, Thesis), Kutty (2010), Bornstein (2010), Pribut (2010), Downey (2010a, b), MacLellan et al. (2011), Arif et al. (2011).

3. Transient quadrupedalism

The most prominent characteristic of the UTS cases was the diagonal-sequence quadrupedalism, which usually started during childhood following a normal hand-knee crawling period at around two years of age. However, a transformation from well-balanced quadrupedalism to ataxic-bipedalism occurred at around 12 years of age in one man, who walks in a bipedal ataxic manner now and has not utilized locomotion on all fours since about 25 years ago. The man was one of six quadrupedal cases in the first discovered family near Iskenderun (Tan, 2005; Tan, 2006a), and the five other cases in the family are consistent quadrupeds.

In addition to this case one man (44 years old) from the Adana 1 family (Tan 2006b, c) exhibited consistent quadrupedalism, while the other man (34 years old) from the same

Families	ISK	AD1	ANT	CAN1	CAN2	KA	AFY	AD2	DI 1-2
N	19	3	29	2	2	2	3	5	22
Men	8	2	16	1	1	2	2	4	13
Women	11	1	13	1	1	0	1	1	9
Age	19-35	27-33	12-46	62-65	22	43-44	10-22	12-21	3-30
N (QL)	6	2	7	2	2	2	3	1	7
Men	2	1	5	1	1	2	2	1	4
Women	4	1	2	1	1	0	1	0	3
Age	19-33	27-37	12-46	62-65	22	43-44	10-22	12	7-25
Locus	WDR81	Ch.13q	Vldlr	Vldlr	Vldlr	(?)	(?)	(?)	(?)
Cerebellum	Hypo.	Normal	Hypo.	Hypo.	Hypo.	Hypo.	Hypo.	Hypo.	Hypo.
DTR upp.	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Hypo.	Norm.
DTR low.	Hyperac.	Hyper.	Hyper	Hyper	Hyper.	Hyper.	Hyper.	Hypo.	Hyper.
Mus. Tone	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Norm.	Norm.
Strength	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Norm.	Norm.
Babinski	+(3/5)	Absent	+(3/7)	Absent	Absent	+ (1/2)	+(1/3)	Absent	+(1/7)
Tremor	Mild	Mild	+(1/7)	No	No	No	No	Yes	No
Nystagmus	Yes	Yes	No	No	No	No	No	No	2/3
Early Hyp.	No	No	No	No	No	1/2	Yes	No	Yes
Speech	Dysar.	Dysar.	No	No	No	Dysar.	No	No	No

Families: ISK: Iskenderun, AD1: Adana1, ANT: GaziAntep, CAN1: Canakkale1, CAN2: Canakkale2, KA: Kars, AFY: Afyon, AD2: Adana2, DI 1-2: Diyarbakir 1 and2. Consang.: consanguinity; QL: quadrupedal locomotion; BL: bipedal locomotion; Atax: ataxia; Vest. imp.: vestibular impairment; cereb.cor.: cerebral cortex; DTR: deep tendon reflex, upp.: upper extremity; low: lower extremity; mus.: muscle; hypo.: hypotonia; exp.: expressive; trun.: truncal; bip.: bipedal; habit.: habitual.

Table 1. Families with Uner Tan syndrome hitherto discovered in Turkey

family transformed from childhood quadrupedalism to ataxic bipedalism at about 14 years of age. In childhood this individual propelled himself backwards on his bottom, and then started ambulation on all fours at about two years of age. These persons with adulthood transformation from quadrupedalism to bipedalism were previously reported as consistently bipedal-ataxic cases. Consequently, these results concerning transient quadrupedalism are not consistent with some minor reports accentuating the existence of purely ataxic bipedal cases among siblings of UTS cases. A transformation from balanced quadrupedalism to ataxic bipedalism also occurred during adulthood. For instance, one of the brothers from the Kars family (now 46 years of age) exhibiting UTS, showed a transition from habitual quadrupedalism to ataxic bipedalism about 20 years ago. (seeTan, 2010b).

4. Dynamics

Dynamics in physics deals with the motion and equilibrium of systems under the action of forces, usually from outside the system; it is an interdisciplinary field in contemporary science now, to analyze the behavior (Strogatz, 2000, p. 2). The system concept, accentuating the relationships between component parts rather than the parts themselves, opened a powerful new perspective in science. The system thinking is valuable because it can help us to create smart, enduring solutions to scientific questions, and because it offers us a more accurate picture of reality. By definition, a system is a group of interacting and interdependent components that form a complex and unified whole.

Systems can be controlled or uncontrolled. In controlled systems, the information is sensed, and changes are effected in response to the information, a process that can be referred to as *detector, selector, and effector*, respectively (Kuhn, 1974). The detector is the sensing part of the system, and is concerned with communicating information between systems, including environment. The selector is the part of the system that processes information and makes decisions, and the role of the decision-making part of a system is to drive the system towards equilibrium. The effector is responsible for the transactions between systems. Communication and transactions are involved in interactions between systems. From two general approaches, *cross-sectional and developmental approaches,* a system developmental approach was the topic of the present work, dealing with the changes in the system over time. To analyze the development of human quadrupedalism, a *holistic analysis* was performed to examine the system as a complete functional unit, instead of a *reductionist approach,* which looks downward and examines the subsystems separately within the system. Properties of any system are: (i) a system consisting of interrelated and interacting parts exists in an environment; (ii) any system has a preferred state; (iii) the components of a system may in turn be systems themselves. Conceptual systems are utilized in analysis, comprehension, and for improvement purposes. All open and closed systems have a preferred state. For instance, atomic oxygen prefers to be molecular oxygen, a business prefers to be profitable, human beings prefer to be physiologically and emotionally satisfied.

5. Complex systems and self-organization

Complex biological systems, such as families, the human body, the brain, etc., consist of interconnected or interwoven parts (Bar-Yam, 1997, p.1). Complex systems in physics, such as ice crystals, galactic spirals, clouds, or lightning flashes, tend to spontaneously generate new organized forms.

Dynamic complex systems have self-organizing properties, following the principle the sum of the parts is greater than the parts taken independently, contrary to Sir Isaac Newton's argument the motion of the whole is the sum of the motion of all the parts. The dynamic complex systems have the tendency to spontaneously self-organize themselves to produce novel patterns. The process of self-organization is the quintessence of all living systems. The evolution of living beings may also be associated with the principles of self-organization, but Darwinism essentially ignores the process of self-organization (see Waldrop, 1990; Oudeyer, 2006).

The self-organization is closely coupled with "emergence," a fundamental property of complex systems, i.e., a new property or behavior…emergence may be considered the product or by-product of the system… the product of interconnections and the interaction makes it dynamic and unpredictable (Dobrescu & Purcarea, 2011). The emergence of unpredictable outcomes within a complex system such as the human body is closely related to neural networks that are "self-organized critically" (Tetzlaff et al., 2010).

By definition, self-organization occurs through the interaction of its components (endogenously) or by some environmental influence (exogenously). self-organization may be triggered by "strange attractors" , which refers to a kind of steady-state in a dynamical system. One type of attractor is the strange attractor, which may be visible, for instance, in the EEG pattern during rest. Another type of strange attractor may be visible in the EEG

during thinking. Other types of strange attractors may be consciousness and personality. The brain as a dynamic system may have many strange attractors, which may show state transitions, thereby creating novel and unpredictable patterns, such as during the postnatal development of children.

The common factor for UTS to trigger a strange attractor, i.e., the diagonal-sequence quadrupedal locomotion may be their disability or difficulty in achieving bipedal upright locomotion. The extremely rare emergence of human quadrupedalism may be associated with the unpredictability of the strange attractors. Concerning the adaptive motor behavior and intentionality, the dynamical systems tend to control the outcome pattern of the system to find a compromise between *which patterns can possibly be built from the system components to begin with, and the structural constraints of the environmental situation;* a synergetic pattern formation—with possible strange attractors—may be "intentional" with the self-organization phenomena being basic explanations for the adaptive behavior (Tschacher et al., 2003).

6. Central pattern generators

Central pattern generators (CPG) are embedded within the spinal cord, responsible for creating a locomotor pattern and generating rhythmic locomotor activity, without being controlled by the supraspinal centers (Grillner & Wallen, 1985; Hooper, 2000; Hiebert et al., 2006). The isolated spinal cord in the lamprey (a primitive fish) can spontaneously produce *fictive locomotion* (Cohen & Wallen, 1980; Grillner & Wallen, 1985), as in salamander (Delvolvé et al., 1999) and frog embryos (Soffe & Roberts, 1982). In contrast to lower vertebrates, the existence of CPGs in higher primates is much less convincing (Duysens et al., 1998), and the concept of CPG did not find supporters among system theoreticians.

The progressive maturation of the locomotor networks (CPGs) in the central nervous system, studied by anatomical and electrophysiological techniques, was previously evaluated by Dr. Douglas Stuart, in a detailed review article (Stuart, 2007). Regarding the spinal CPGs operating in human beings, there is only indirect evidence. Locomotor-like movements were recorded in human fetuses at 10 gestational weeks, and neonatal infants often exhibit stepping movements if supported (McGraw, 1945, pp.22-23). However, this first stepping ability subsequently disappeared for many months due to mechanical (Thelen & Fisher, 1982) or neuro-developmental factors (Forrsberg, 1985). On the other hand, the CPGs are not static, previously hard-wired, firmly established systems, but instead they are rather loosely organized neural networks under the influence of the dynamically changing chemical and/or sensory control, resulting with many newly emerged functional circuits (Selverston, 1988, cited by Kelso, 1995, p.243).

In contrast to the theory of stage-like motor and cognitive development, the perspective of behavioral-motor development as a self-organized process seems to be more plausible to explain why and how infants walk within a particular environment (see for review Thelen & Ulrich, 1991). That is, a previously coded neural network, i.e., neural coding, seems to be unlikely, because of the lack of precise point-to-point wiring in the central nervous system with immense overlaps of dendritic and axonal arbors. The integrative neuroscience emphasizes the "*inside-out*" and "*outside-in*" approaches for the understanding of locomotor control (see Stuart, 2007).

7. Motor development

Needham (1959) reported that over 2000 years ago Aristotle was one of the first people studying embryonic development systematically. He examined embryos of different organisms by opening up birds' eggs, and by studying mammalian and possibly human embryos at different developmental stages. In Aristotle's philosophy, *movement* is a central concept, which means much more than being a merely mechanical process, as emphasized by Tan (2007) in his psychomotor theory.

During embryonic development of the CNS, the large neurons, such as the Purkinje cells in the cerebellar cortex, and the pyramidal cells in the cerebral cortex, are generally produced before the small neurons and the small neurons (interneurons) emerge last during neural development in utero. Also, motor nuclei commence their histogenesis and complete their cell populations before the sensory nuclei (Brown et al., 1997). The thickness of the cerebral cortex steadily increases during in-utero development, and the Broca's area rapidly grows through the first postpartum month, reaching the adult thickness when the child is around four years of age. The pyramidal cells in the cerebral cortex actually start to differentiate by 25 weeks of gestation, but without basal dendrites, with only tortuous apical dendrites. The first synapses in the human cerebral cortex appear at about 23 weeks of gestation (Molliver et al., 1973). The pyramidal cell morphology is completed at about three years of the postpartum development of the human cerebral cortex. The small pyramidal cells mature at the last trimester, during which spines also appear on the dendrites, with a tenfold increase in the dendritic trees during the same time span. Finally, as the neuronal projections approach their final structures, regressive events such as cell death, axonal pruning, and synaptic elimination, occur in the central nervous system (Cowan et al., 1984). Actually, during the embryonic phase of in-utero development, many more neurons are produced than are present in the mature central nervous system. However, while making synaptic connections of their axons, many neurons (about half of them) are eliminated by selective cell death (Oppenheim & Chu-Wang, 1983), which rapidly occurs within a few days. *Programmed cell death is genetically determined but may be influenced by functional changes such as motor activity or inactivity and by the size of the target group of neurons* (Brown et al., 1997, p. 15). The purpose of the programmed cell death may be the elimination of axons incapable of reaching the target, to avoid or clean the connection errors.

With regard to in-utero fetal movements, the first modern concept of the origin of the prenatal movements interestingly originated from Preyer as early as in 1885 (cited by Schröder & Young, 1995). Preyer concluded that the spontaneous fetal movements may start long before the 12th week of gestation, not being associated with peripheral stimuli, suggesting an important function of this spontaneously generated fetal motility in the ontogeny of the organism.

Children were classified according to the development of muscle response synergies, as follows (Woollacott & Sveistrup, 1992; Sveistrup & Woollacott, 1993): pre-sitting in 2-6 months, early pull-to-stand in 7-8 months, pull-to-stand in 9-10 months, independent stance in 10-12 months, independent walking in 12-14 months, and late independent walking in 14-16 months. Postural control may be impaired in children with cerebral palsy, due to an injury to the cerebral cortex resulting from anoxic or hypoxic encephalopathy, intracerebral hemorrhage, and CNS neuropathy resulting from malformation (Olney & Wright, 1994). The stretch reflexes are always exaggerated in children with cerebral palsy. The functional

significance of these hyperactive stretch reflexes is the subject of debate. Accordingly, Nashner et al. (1983) did not find a correlation between stretch reflex abnormalities and functional ability, and questioned the role of the stretch reflexes in postural control. This is expected from the system perspective: many subsystems are dynamically interacting during postural development within the context of the task and environment.

Humans with or without quadrupedalism may share similar CPGs with other quadrupeds, because they are all using the common neuronal control mechanisms for locomotion (Shapiro & Jungers, 1994). Accordingly, Dominici et al. (2011) selected the basic discharge patterns of lumbosacral motoneurons during stepping of neonates, toddlers, preschoolers, and adults. These authors found *two basic patterns of stepping neonates are retained through development… Markedly similar patterns were observed also in the rat, cat, macaque, and guinea fowl, consistent with the hypothesis that, despite substantial phylogenetic distances and morphological differences, locomotion in several animal species is built starting from common primitives, perhaps related to a common ancestral neural network…*(p.997). For animals with diagonal-sequence quadrupedal locomotion, these ancestors may be extended to the first emergence of tetrapods during the Devonian period, about 400 million years ago. In other words, the basic neural networks that emerged about 400 million years ago in the first tetrapods during transition from water to land seem to be conserved in animals with diagonal sequence quadrupedal locomotion from primitive quadrupeds up to the primates including human beings. Stuart (2007) emphasized the need to *"… give equal attention to issues raised concerning the motor control of a variety of animal phyla, classes and species (Stuart, 1985, p.96; Stein, 1999). It has proven to be heuristic value to indicate when common principles of motor control are present across phyla (Pearson, 1993), when evolutionary deviations have occurred (Fetcho, 1992).*

8. Maturation theory

During the first half of last century motor development was approached by longitudinal studies to show the sequence of motor behaviors in infants and young children. This maturation theory was mainly elaborated by Gessel (1928), Shirley (1931), and McGraw (1932, 1943), who searched for rules governing the order of changes during motor maturation. Konner (1991) stated *motor development sequences are largely genetically programmed.* Forssberg (1985) explained the disappearance of the neonatal stepping and its reemergence by the maturation of the supraspinal centers, suggesting that the neural code has been retained in humans since the earlier evolutionary periods. The development of early motor behaviors was also attributed to the maturation of the cortico-spinal pathways (von Hofsten, 1984; Jeannerod, 1988).

Although the maturation theory added some valuable information to the basics of motor development, it was far from explaining the dynamics of locomotor development, especially with regard to the behavior in real time and the process of change. In this context, Ulrich (1997) stated *it is not at all clear how genetic codes can be translated into even simple patterned neural organization… behavior is much more than a simple neural pattern* (p.321).

To be able to solve the problems related to development, one must consider the properties of complex systems with many dynamically interacting individual parts. Dynamic systems theory is involved in such an approach, which seeks to understand the behavior of a system, not by taking it as separate parts, but by taking these parts to see under what circumstances

they dynamically cooperate to induce a whole pattern (Thelen, 1996). The most important basic characteristic of dynamic systems theory is that behavioral patterns such as locomotion can emerge spontaneously from the dynamic interaction of multiple subsystems or components; detailed plans or neural codes are not represented *a priori* in the brain, nor are the movement patterns, such as walking and running, from the maturation of fixed CPGs. From the dynamic systems perspective, the developmental emergence of human locomotion is also self-organizing, as in other complex systems. *Multiple subsystems, intrinsic and extrinsic, contribute to behavioral outcomes. for example, neural organization, muscle strength, joint structures and ranges of motion, motivational and arousal levels, the support surface, and the task… the coordination pattern emerges spontaneously, and is self-organized and opportunistic* (Ulrich, 1997, p.324). The classical example of self-organization is Thelen's (1986) discovery showing a-month-old child exerting stepping on a motor-driven treadmill when supported upright. The child's stepping on the treadmill occurred under the influence of multiple subsystems. That is, the sensory receptors first detect the dynamics of the context, and then send the information to the motor neurons through interneurons to activate the muscle synergies, comprising the intrinsic subsystems that contribute to the locomotor behavior. The treadmill belt, the supplemental postural control and weight support provided by the experimenter are extrinsic subsystems.

9. Neuronal group selection theory

In the field of motor control, better understanding of neurophysiology caused a gradual shift from the concept that motor behavior is largely controlled by reflex mechanisms towards the notion that motility is the net result of complex spinal or brainstem activity. It was assumed that motor control of rhythmical movements like locomotion, respiration, sucking, and mastication may be based on CPGs. The activity of the networks, which are usually located in the spinal cord or brainstem, is controlled from supraspinal areas via descending motor pathways. The supraspinal activity itself is organized in large-scale networks in which cortical areas are functionally connected through direct recursive interaction or through intermediary control or subcortical (striatal, cerebellar) structures. Consequently, theoretical frameworks for the processes involved in the development of motor control include two major but current and conflicting theories: neuronal maturationist theories and the dynamic systems theory. There is also a third theory, the neuronal group selection theory, which combines the "nature" part of the neural-maturationist theories with the "nurture" part of the dynamic systems theory (Hadders-Algra, 2000).

It was believed in the mid-1990s that the maturation of the CNS progressively occurred through the genetically predetermined neural patterns, in the cephalocaudal and central-to-distal direction; the locomotor development was regarded as a result of the progressively maturated and hence increased cortical control on the spinal reflexes. That is, it was believed that standing and walking result from the cerebral maturation, which is genetically predetermined and not learned by experience. McGraw (1943) considered the locomotor development from a convergent action of "nature" and "nurture". More controversially, Thelen and Ulrich (1991) did not accept the neural-maturationist theories, asking how can the timetable of motor solutions be encoded in the brain or in the genes?

The contemporary ideas about neuronal maturation actually originated from Bernstein (1935), who tried to understand how the CNS solves the problem of locomotor coordination, and

argued that the production of locomotion involves hundreds of muscles and joints, which require specific computational techniques of the nervous system. Kelso et al. (1981) utilized the dynamic systems theory to explain the developmental emergence of locomotion in human beings. These authors suggested that a behavior, such as a locomotor pattern (quadrupedal or bipedal), may result from the combined dynamic effects of, for instance, muscle strength, body weight, postural support, motivation, and brain development, in addition to the environmental initial conditions and task requirements (see also Thelen, 1996; Ulrich, 1997).

Transitions in locomotor behavior, best exemplified in the transition from quadrupedalism to bipedalism in some UTS patients (see above), may occur due to the innate dynamics of the complex systems. Thelen (1996) suggested that the locomotor development as a dynamic system may be considered as a self-organizing process, a series of states of stability, instability, and phase shifts in the attractor landscape, reflecting the probability that a pattern will emerge under particular constraints. In summary, the neural maturationist theories consider the maturational state of the nervous system as the main constraint for developmental progress, whereas in the dynamic systems theory the neural substrate plays a subordinate role (Hadders-Algra, 2000).

The variability in developmental processes, such as motor performance, developmental sequence, or the duration of developmental stages, was emphasized to explain the development by the Neuronal Group Selection Theory (NGST) (Edelman, 1993; Sporns & Edelman, 1993). Neuronal groups are collections of many hundreds or thousands of neurons interconnected by excitatory and/or inhibitory synapses as well as the excitatory and/or inhibitory recurrent feedback circuits. According to the NGST, the functional and structural properties of neuronal groups are determined by evolution. However, the repertoires are variable because of the dynamic epigenetic mechanisms regulating cell division, adhesion, migration, apoptosis, and extension and retraction of neuronal arborizations. Behavior and experience, such as during locomotor development, produce afferent information for the cerebro-spinal locomotor system. This afferent information is used for the neuronal selection induced by changes in the excitatory and inhibitory levels of the synapses and in the intergroup connections within a particular neuronal group. The experiential afferent information induces modifications in the strength of the synaptic connections within and between the neuronal groups resulting in the variable secondary repertoire. The changed connectivity within the secondary repertoire allows for a situation-specific selection of neuronal groups. Thus, the secondary neuronal repertoires and their associated selection mechanisms form the basis of mature variable behavior, which can be adapted to environmental constraints (Hadders-Algra, 2000). The NGST emphasizes the role of the complex information processing originating from an intertwining of information from genes and the environment, which is inconsistent with the "nature-nurture" debate. During motor development in early fetal life, the spontaneous movements (primary variability), i.e., the self-generated motor activity with the consequent self-generated afferent information, may explore all the locomotor possibilities within the neurobiological and anthropometric constraints within the CNS, preserved during evolution.

During postnatal development, all of the intentional motor behaviors are within the frame or in the phase of "primary variability". This developmental phase is characterized by synaptogenesis, which is especially prominent in the cerebral cortex (Huttenlocher et al.,

1982; Rakic et al., (1986). The primary networks developed during this phase are suitable for the selection of the appropriate locomotor circuits, and are indeed associated with ample variations in locomotor activities such as crawling. The neural systems with specific functions can explore all motor possibilities available for the specific intentional motor function. Consequently, the most efficient motor pattern gradually emerges following exploratory and continuous information processing activities within the CNS. The time-sequence for the selection process changes with function, such as the second half year after birth for arm reaching; the postural activity of neck and trunk muscles are direction specific before infants can sit independently at about four to five months of age. Selection of the most efficient postural adjustment in which all direction-specific neck, trunk, and proximal leg muscles are activated, occurs during the third postnatal trimester (Hadders-Algra et al., 1996), which can be accelerated by exercise for balance, facilitating the selection process (Hadders-Algra et al., 1996). The most efficient postural balance selection occurs much later between 12 and 18 months of age.

The establishment of the secondary (sub)cortical repertoires is mainly associated with neural rewiring, which may occur through synapse formation, synapse elimination, increase or decrease in dendrites, their arborizations, and spine number on the dendrites. The long duration of the developmental processes within the brain suggests that long-lasting experiences are needed for the establishment of the secondary neuronal networks, for an efficient motor solution to develop for each specific situation. Children, in general, exhibit non-optimally adapted motor behavior with considerable variation, which negatively correlates with age; small adult values of variation are first reached in adolescence (Forssberg & Nashner, 1982). This may be associated with the late-onset quadrupedalism in some UTS cases, who had never been subjected to any kind of walking exercise, either in infancy or in adolescence or adulthood. Actually, exercise may be beneficial for the selection of the most effective strategy out of the repertoire of adaptive motor strategies, by reducing the amount of secondary variation (Pedotti et al., 1989). The reverse occurs in the absence of exercise, by increasing the motor variation, similar to the UTS cases with no exercise at all. Motor development in light of NGST is summarized below (from Hadders-Algra, 2000):

1. *Primary Variability* (during fetal life and infancy; high variability in motor behavior): the neural system explores, by means of self-generated activity, and consequently, by self-generated afferent information all motor possibilities become available within neurobiological and anthropometric constraints set by evolution.
2. *Selection* (reduced variation, occurring during infancy, at function specific ages): experiential selection of most effective motor patterns and their associated neuronal groups with transient minor reduction in variation of motor behavior.
3. *Secondary or adaptive variability* (from two to three years of age to adolescence): Creation of secondary neural repertoires due to a multitude of experiences, and *Mature situation:* Task constraints: ability to adapt each movement efficiently to task-specific conditions.

The developmental NGST is closely coupled with the concept of the adaptive self-organization. Namely, developmental selection is the differential survival and proliferation of developmental units. This type of internal selection has been proposed as an explanation for diverse examples of self-organization, from the wiring of brains to the formation of pores on leaf surfaces (Frank, 1997).

10. Dynamics of locomotor development in humans

The contemporary views on the development of locomotor skills accentuate the role of the self-organizing processes within the scope of dynamic systems. As mentioned above, the neural networks playing a role in the diagonal-sequence quadrupedal locomotion have existed since about 400 MYA during the Devonian period, having arisen with the first appearance of the ancestral tetrapods. Namely, this type of locomotion is indeed phylogenetically oldest locomotor trait of tetrapods (four-legged animals). Their fossilized 395 million years old bodies were recently discovered across a Polish coast (Niedzwiedzki et al., 2010). From the fossil tracks left by a tetrapod-like animal it was concluded that this animal walked with diagonal strides, reflecting the lumbering locomotor movements like their fishy ancestors living in marine environments (Fig. 5).

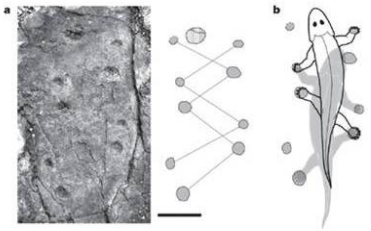

Fig. 5. Trackways. **a:** Muz. PGI 1728.II.16. (Geographical Museum of the Polish Geological Institute). The trackway shows hand and foot shapes in diagonal stride pattern; **b:** a generic Devonian tetrapod fitted to the trackway. Notice the lumbering diagonal sequence quadrupedal locomotion of this tetrapod, similar to its ancestral forms living in water.

Interestingly, the quintessence of this kind of locomotion, did not change during evolution, through salamanders and tuataras (Reilly et al., 2006), till the emergence of non-human primates and even human beings exhibiting diagonal movements between arms and legs even during upright walking (Donker et al., 2001). Fig. 6 illustrates three healthy humans exhibiting diagonal-sequence arm-leg movements during upright-bipedal (above) and requested quadrupedal locomotions (below).

Thus, it may be concluded that the neural generators for diagonal-sequence quadrupedal locomotion may already be present in more or less stable forms in the complex neural systems of primates, including humans. From a systems perspective, it may be argued that the locomotor patterns such as human quadrupedalism may emerge through exploration of available solutions, such as the ancestral neural generators for quadrupedal locomotion and then selection of preferred patterns, such as the ancestral CPGs (Gibson, 1988; Sporns & Edelman, 1993; Thelen & Corbetta, 1994; Turvey & Fitzpatrick, 1993). Following this ontogenetic theory, it may be suggested that the prenatal and postnatal emergence and development of diagonal-sequence quadrupedal locomotion in human beings may be the result of an exploration and subsequent selection process following the principles of the self-organizing dynamic systems (see also Chang et al., 2006).

In the individuals exhibiting UTS, the cases seem to be unable to make the transition from the infantile stage of quadrupedal crawling to upright standing and bipedal walking. Since

they are unable to walk upright due to severe ataxia, their brain then explores the possible solutions during locomotor development, but cannot select the ideal locomotor pattern for upright bipedal walking. Instead, their brain can select only one locomotor pattern for their locomotor activities, which is already present since about 400 MYA. This is the diagonal-sequence quadrupedal locomotion emerged during Devonian period. This walking pattern may also be unstable initially, but becomes stable with practice during childhood, after which they are able to move with great ease, speed, and well-developed balance. On the other hand, the locomotor self-organizing process may take a long time in cases with late childhood emergence of quadrupedal locomotion at about puberty (12-14 years), a period associated with hormonal changes with beneficial effects on the motor system, accelerating the self-organizing processes and resulting in the emergence of a most suitable locomotor pattern to travel around, which in their case is walking on all four extremities (see Tan et al., 2010).

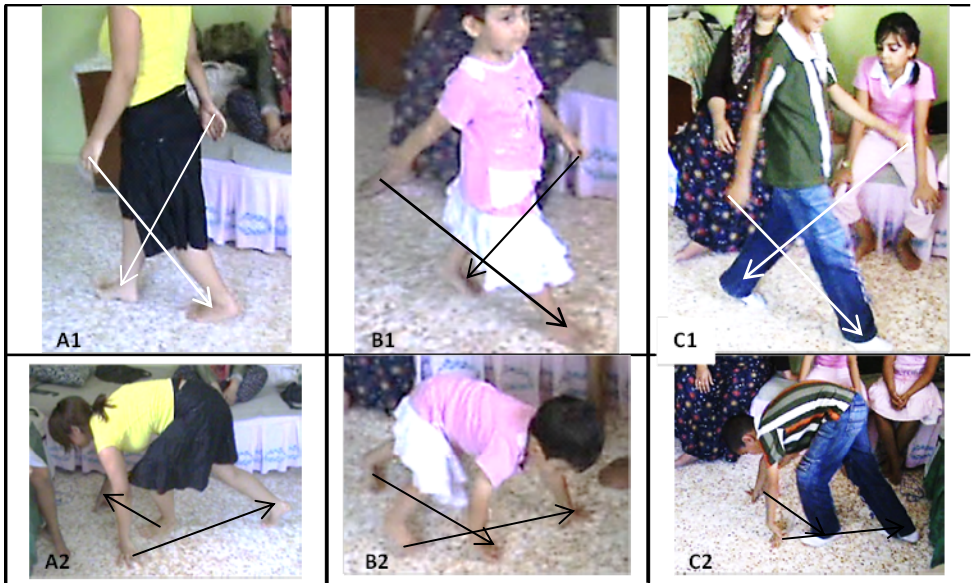

Fig. 6. Diagonal-sequence arm-leg movements (left hand-right foot *vs* right hand-left foot) during walking on two legs (above, bipedal gait) and walking on all four extremities (below, quadrupedal gait) in normal individuals. A1, A2: girl 17 YA; B1, B2: girl 4 YA; C1, C2: boy 14 YA. Photographs are curtesy from Derya Deniz Elalmış (post-doc fellow).

There is another example of the endurance of the adaptive self-organizing processes in the central nervous system through adulthood, namely, two brothers (43 and 44 years of age) with UTS reported by Tan (2010b). One of the brothers exhibited consistent quadrupedalism, but the other exhibited a transition from quadrupedalism to bipedalism despite a mild ataxia, and was able to travel with the aid of a walking stick by early adulthood (20 years of age). Similarly, there was one man in the Iskenderun family (Tan, 2005, 2006a) with a transition from quadrupedalism to late childhood ataxic-bipedalism, and one man in an Adana family with a transition from childhood quadrupedalism to adulthood

ataxic-bipedalism (Tan, 2006b, c). In this context, i.e., transition from quadrupedalism to bipedalism, Nakajima et al. (2004) reported *the animal (Japanese monkey) can also learn to transform its locomotor pattern from quadrupedality to bipedality, and vice versa. This monkey can select a postural strategy appropriate for the execution of both gaits* (p.183).

Interestingly, there were two bright children, with entirely normal brains and cognition, who exhibited facultative quadrupedal locomotion: bipedal walking for everyday activities, but quadrupedal running for speedy actions (Tan & Tan, 2009). Apparently, their adaptive self-organizing brains explored the available solutions for slow and fast locomotion, with subsequent selection of the preferred patterns for traveling around. These outside-in mechanisms (see Stuart, 2007) may involve mesencephalic and subthalamic regions, cerebellum, basal ganglia, and hypothalamus (see Takakusaki et al., 2006); the posterior parietal cortex may plan the travel and the motor cortex may contribute to traveling through fields with obstacles (Drew et al., 2008), allowing the necessary modifications during traveling, and utilizing the adaptive self-organizing processes to explore, select neural groups, and execute the preferred locomotor patterns. For the adaptive self-organization in the brain, dynamic instability, a form of complexity, is typical for the neuronal systems (Friston, 2000a, b, c), allowing the selective consolidation of synaptic connections within the selected neuronal groups (Edelman, 1993).

11. Concluding remarks

The first phase in the development of locomotion, primary variability, would occur in normal fetuses and infants, and those with UTS. In both normal and pathological cases, the primary neural repertoire would be set by evolutionary epigenetic mechanisms inherited from the very primitive tetrapods with diagonal-sequence quadrupedal locomotion that lived nearly 400 MYA. The neural system can explore all motor possibilities by means of the self-generated, spontaneous motor activity and consequently occurring self-generated afferent information transmission within the neuronal system. The neural networks for quadrupedal locomotion have apparently been transmitted epigenetically through many species since about 400 MYA, and may be readily available for the next phase of motor development.

The second phase is the neuronal selection process. During infancy, the most effective motor pattern(s) and their associated neuronal group(s) are selected through experience. The normal and UTS cases begin to differentiate in this neuronal selection phase, the former selecting the neuronal groups required for bipedal motor patterns, the latter still selecting and/or improving the neuronal groups required for a better developed and balanced diagonal-sequence quadrupedal locomotion, which was epigenetically inherited during evolution over the last 400 MYA or so. The infants with UTS cannot select the appropriate neural networks for bipedal walking, since some of the neural structures necessary for well-balanced upright walking are damaged in infants with UTS, due to cerebellar hypoplasia, and less prominent cortical gyral simplification.

The third phase, secondary or adaptive variability, starts to bloom at two to three years of age and matures in adolescence. During this phase the secondary neural repertoires are created as a result of a multitude of motor experiences, and each movement is adapted exactly and efficiently to task-specific conditions. In cases with UTS within the same age

range in the secondary or adaptive variability phase, the secondary neural repertoires cannot be created, and instead, they keep the more primitive motor repertoires from the first primary variability phase and the selection phase, exhibiting only the ancestral neuronal groups responsible for the ancestral diagonal-sequence quadrupedal locomotion. The secondary or adaptive variability phase may be utilized by experience only for improving on the previously selected quadrupedal locomotor pattern. This third phase may last much longer in some patients, with a considerable delay in selection of the well-balanced quadrupedal locomotion, which may emerge very late in adolescence in these cases.

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Section 2

Human Development: The Context for Ontogenesis

4

Human Development with Fractional Mobility

Atanu Sengupta and Abhijit Ghosh
Department of Economics, Burdwan University, Burdwan, West Bengal India

1. Introduction

The general concern in human development is overall change. However such changes often camouflages subtle micro-dynamics that may yield different story altogether. The partial mobility indices have been developed by Sengupta and Ghosh (2010) for this purpose.

Economists have been using mobility analysis for a long time. As argued by Quah (1993), such temporal movements may reveal patterns that are not always discernable when one considers the time movement in the aggregate. For example, the traditional analysis of per capita GDP growth veils the movement of different income groups.

The importance of positional mobility indices can be well illustrated using the following cases discussed by Dasgupta (2008). There he considered the story of two girls-one Becky in a suburban town of American Midwest and a Desta in rural Ethiopia. He argued that the lives of these two girls (who are "intrinsically very similar" Dasgupta (2008)) are so distinct from each other that they could be imagined to inhabitate different worlds. He describes Desta's world as follows:, "Desta knows well that she will be married (in all likelihood to a farmer, like her father) when she reaches eighteen and will then live on her husband's land in a neighboring village. She expects her life to be similar to that of her mother." In the terminology of mobility analysis, Desta finds herself in a perfectly immobile position. In contrast, Becky's world is depicted as a dynamic changing world. "Becky's parents also remark that her generation will be more prosperous than they." In conclusion, Dasgupta (2008) asserts, "In this article, I have used Becky's and Desta's experiences to show how it can be that the lives of essentially very similar people can become so different."

What is important here that these otherwise identical girls differ in one crucial aspect-they visualize life from different positional standpoints. The difference between the standpoints is so different that it hardly depends on the types of data we use for analysis or on the methodology we use (uni-dimensional or multi-dimensional). In speaking of positional objectivity, Sen (1993) speaks of a major ontological departure.

Sengupta and Ghosh (2010) have been able to construct positional mobility indices by developing a set of axioms that differs sharply from Shorrocks' (1978) original axioms for mobility. The positional mobility indices are termed as partial because they give only a partial picture without saying much about the whole. However these partial indices do not speak much about the magnitude of movement. For example, the probability for moving out of the lowest possible case may be 0.9 for both countries A and B indicating partial mobility

of equal magnitude. However the picture might not be so simple. For A, it means a 0.9 probability of moving to the immediate (slightly better off) group, though for B there is a 0.5 probability of moving to the more far-away cells (with 0.4 possibility of moving to the immediate cell). These magnitude differences are neglected in the partial mobility approach. Hence, we need to develop the concept of fractional mobility. This task is attempted here.

The paper is divided into five sections. Section II incorporates the new framework in the context of mobility index. It is divided into two sub-sections. In the first subsection we argue that a partial and relative measure is appropriate for analysis of human development. In the next subsection our approach is developed formally. Section III develops the new concept of fractional mobility. Section IV gives our empirical analysis of the world level performance of individual country in the context of human development according to our approach. Section V gives an example from the social field. In section VI, we conclude our study.

2. Partial mobility in human development-some methodological issues

2.1 Positive partial mobility

Aggregate (or overall) mobility indices may be quite satisfactory when we analyse certain economic phenomena (such as unemployment-where lesser mobility in the employment state is preferred) (Bhattacharya 1995). However they are clearly inadequate in the analysis of components of Human Development Index[1] (such as income, life expectancy or literacy rate).

We construct an example to substantiate our viewpoint. Consider a simple economy with three states. The mobility matrix is as follows

$$\mathbf{P}^{ex} = \begin{pmatrix} 0.8 & 0.1 & 0.1 \\ 0.2 & 0.1 & 0.7 \\ 0 & 0.8 & 0.2 \end{pmatrix}$$

A very popular mobility measure given by Shorrocks (1978) is as follows $M_D(P) = 1 - |\det(P)|^{\alpha}$ where det (P) is the determinant of P. Taking α=1, we get $M_D(P^{ex}) = 0.58$. Now what does this mean? It means that the overall mobility in the society is 0.58 that is neither very bad nor very good. Now consider the mobility experience from the point of view of the group that belonged to the lower state at initial time period. To them, there is only a 0.2 probability of moving upwards. Hence this group will view the mobility to be rather low. For those in the middle state (at the initial period), on the other hand, there is a high probability of moving upwards (0.7) and a negative mobility (that is the probability of moving downwards) of a negligible degree (0.2). For those belonging to the highest category there is only a 0.2 probability of remaining at the initial state. Thus these three groups have entirely different mobility experiences that cannot be captured by the overall mobility measure $M_D(P)$. **Our choice of this measure is only for illustrative purpose**. We could have selected any other such popular measures instead giving roughly the same result. What we

[1] Quah (1993) pioneers the use of income mobility matrix for evaluation of social purposes in his study of global inequality.

argue is that a single mobility measure cannot capture different mobility experiences that different groups face in the field of human development. We should instead move on to the **partial mobility measures** that try to capture group-specific mobility[2].

The alternative framework emphasises on the mobility from the view point of a particular section of the society. In our analysis each interval (or class) represents a particular section. Since each row corresponds to an interval at the time period *t*, mobility with respect to a row chalks out the movement of that interval over the entire time point. There will thus be (*k*-1) partial mobility indices[3] $M^i(P)$ with $i = 1,2.....k-1$. Each index summarizes the mobility from the point of view of the *i*th class. We can define $M^1(P)$ to be the **Rawlsian Ethical Mobility Index (REMI)**-viewing mobility from the most deprived category. Similarly we can define $M^{k-1}(P)$ to be the **Elitist Ethical Mobility Index (EMI)**-viewing mobility from the next to the best-endowed category[4].

In defining these mobility indices, it must be stressed that unlike the simple mobility measure here not only the degree but also the direction of change is important. Hence it is necessary to bring some ethical dimensions in mobility. In order to grasp the problem more concretely we argue that **only** movements from a **lower cell** to a **higher cell** should entail an improvement in social welfare. These partial mobility indices may be regarded as **Positive mobility indices**- they measure improvement in the social welfare.

We posit the following axioms for the positive partial mobility indices:

(A.1) **Normalization (NO):** 0≤ M(P) ≤1. This is a very mild assumption (Bhattacharya 1995). It implies that M(P) lies between zero and unity.

(A.2) **Ethical Monotonocity (EMO)**: **EMO** will imply M(P)>M(P*) if any of the two axioms are true (i) $p_{ij} \geq p_{ij}^*$ for all $i < j$ and (ii) $p_{ij} = p_{ij}^*$ for some $i < j$.

EMO indicates that for monotonicity we concentrate only the particular row (or position) whose mobility we are concerned with. Ideally then a rise in at least one of the non-diagonal p_{ij} for that row should increase the partial mobility.

(A. 3) **Ethical Immobility (EI):** $M^i(P)=0$ when the probability of staying at the i^{th} position is unity. In other words $M^i(P)=0$ when $p_{ii} = 1$.

We can posit a still milder version.

(A. 3)// **Ethical Partial Immobility (EPI):** $M^i(P)=0$ when there is zero probability for any observations (belonging to the i th row) to move to any higher cell. **EPI** ensures that $p_{i/j} \forall j > i^{/} = 0$.

We can again see that if $p_{ii} = 1$, **EPI** is valid. However **EPI** is true, even when $p_{ii} \neq 1$. A logical beauty of **EPI** is that it brings us straight forward to the opposite case of perfect mobility. The relation between these two extreme cases is succinctly brought out in our case.

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[2] Aggregating individual viewpoints to get an overall picture will bring forth the traditional social choice problem that is beyond the scope of this paper.

[3] Here we are discussing only *positive mobility indices*-that is a natural extension of Shorrock's (1976, 1978) measures. The discussion of *negative mobility* is done later.

[4] In certain cases the lowest feasible category may not exist at time point *t*. In this case we may move on to the least observable category. Similarly argument may be extended for the highest feasible category *k*.

(A. 4)/ **Ethical Perfect Mobility (EPM)**: $M^i(P)=1$ when there is zero probability for any observations (belonging to the i th row) to move to any lower cell. **EPM** ensures that $p_{i/j}\forall j \le i/ = 0$ [5]

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From this we can now precede to our construction of a set of partial mobility indices.

We suggest a set of positive partial mobility measures $M_+^i(P)$ as follows

$$M_{o+}{}^i(P) = \sum_{j=i/+1}^{k} (p_{i/j})^\alpha \tag{1}$$

where $\alpha \ge 1$.

The parameter α may be defined as the mobility elasticity. Given the probabilities, higher the α, higher the mobility.

2.2 Negative partial mobility

So far we considered only the issue of immobility or moving towards a better position. We may call this as an **optimistic view**. However there is another possibility that was nascent in our example- the question of deterioration or moving down to a lower cell. Thus we introduce the fact that a movement from a higher cell to a lower cell could result in a fall in welfare and label it as **negative mobility.** We regard this as a **pessimistic view**. As before there will be (k-1) partial negative mobility indices $M_-^i(P)$ with $i = 2\ldots\ldots k$ (in the stronger version).

For negative partial mobility the axioms are:

(A.2)// **Negative monotonocity axiom** (**NMO**): **NMO** will imply M(P)>M(P*) if the following relations are true (i) $p_{ij} \le p_{ij}^*$ for all $i > j$ and (ii) $p_{ij} = p_{ij}^*$ for some $i > j$.

However unlike **EMO, NMO** will fail to be a subset of **MO**.

Considering immobility, we note that both **I** and **EI** are applicable even for negative mobility indices. However the axiom **EPI** has to be turned upside down in order to accommodate negative mobility indices.

(A.3)/// **Ethical Partial Negative Immobility (EPNI):** $M^i(P)=0$ when there is zero probability for any observations (belonging to the i th row) to move to any lower cell. **EPM** ensures that $p_{i/j}\forall j < i/ = 0$.

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[5] This certainly means that **EPM** seems to imply total indifference to what happens to the various probabilities of upward mobility. An introduction of such a preference pattern will necessitate the concept of weighted partial mobility indices. We refrain from such an exercise in this paper.

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As with positive mobility, this axiom logical leads to the perfect mobility axiom from the negative side- Ethical Perfect Negative Mobility (**EPNM**).

(A.4)// **Ethical Perfect Negative Mobility (EPNM)**: $M^i(P)=1$ when there is zero probability for any observations (belonging to the *i* th row) to move to any higher cell. **EPNM** ensures that $p_{i'j} \forall j \geq i' = 0$ [7]

We suggest a set of (negative)[8] partial mobility measures $M_{-}^{i}(P)$ as follows

$$M_{o-}{}^{i}(P) = \sum_{j=1}^{i'-1} (p_{i'j})^{\alpha} \tag{2}$$

where $\alpha \geq 1$.

We note that this measure satisfies **NO, EMO, I, EI** and **EPNI.** It is also true that the partial mobility indices $M_{o-}^{i}(P)$ satisfy **EPNM** if $\alpha = 1$. However, the result does not carry over to the generalised mobility index (6) with $\alpha > 1$.

2.3 Net mobility

Thus we have discussed both the optimistic and the pessimistic view of mobility. It is possible to interpret the positive mobility indices $M_{+}^{i}(P)$ as capturing the *pull factors*-the factors that pulls up a group to a better position. On the contrary, the negative mobility indices $M_{-}^{i}(P)$ summarize the *push factors*- the factors that push down a group to a worse position. The interest lie in assessing the net effect- whether the pull or push factors are stronger.

Now, for net mobility the axioms are:

(A.1)/// **Modified Normalization (M-NO):** $0 \leq \left| NM^i(P) \right| \leq 1$.

The immediate implication of this axiom is simple: $-1 \leq NM^i(P) \leq 1$. In essence then there are three extreme values of $NM^i(P)$- (i) the perfect immobility- $NM^i(P)=0$, (ii) the perfect positive mobility- $NM^i(P)=1$ and (iii) the perfect negative mobility- $NM^i(P)=-1$.

Thus the twin aspects of mobility are well captured within a single measure. The same should apply for Monotonicity (**MO).** The appropriate monotonicity axiom for the net measure should capture both these aspects. We now set to define it.

(A.2)/// **Modified Monotonicity (M-MO): M-MO** implies[9] $M(P)>M(P^*)$ if at least one of the relations are true:

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[7] This certainly means that **EPNM** seems to imply total indifference to what happens to the various probabilities of downward mobility. An introduction of such a preference pattern will necessitate the concept of weighted partial mobility indices. We refrain from such an exercise in this paper.

[8] The adjective positive is cleared now.

(i) $p_{ij} \geq p^*_{ij}$ for all $i < j$ and $p_{ij} = p^*_{ij}$ for some $i \neq j$

(ii) $p_{ij} \leq p^*_{ij}$ for all $i \geq j$ and $p_{ij} = p^*_{ij}$ for some $i \neq j$.

Thus the partial net mobility index satisfying **M-MO** turns out to be[10]: $M^i(P) = f(p_{ij} | i < j) - g(p_{ij} | i \geq j)$.

We are now in a position to define net partial mobility indices[11] NM^i(P) as follows:

$$\text{NM}^i(\text{P}) = M^i_+(P) - M^i_-(P) \tag{3}$$

This measure satisfies both **M-NO** and **M-MO.**

For this paper, we have considered only net *REMI* (Strong positive and weak negative version) and net *EMI* (Weak positive and strong negative version)[12]. These two ethical mobility indices are used to study global experience with human development in the recent decades.

3. Fractional mobility

A neglected issue, so far, is the magnitude of this change. A positive (negative) movement of smaller magnitude would obviously be less attractive than a movement of large magnitude. It is not only important to study whether there is a movement at all but to know how far they have moved. We provide three justifications for the importance of magnitude in partial mobility.

First, there is the logic of perceptible changes- changes that may be perceived to have some impact (positive or negative) on the destiny of the units whose mobility we are interested to study. In a dynamic society change is endemic. All types of changes are not equally significant. Suppose a researcher observes that literacy rate of a particular community have increased by only 0.01% over a period of 10 years. It is almost obvious that such an increase will be deemed insignificant in the sense of reducing the knowledge deprivation. In order to have any meaningful impact the literacy rate should improve by a minimum certain amount as prefixed by the researcher. Similar arguments may be provided for other aspects of human development.

The second argument is derived from the literature of poverty traps (Azariadis and Stachurski 2005, Dasgupta 2009). The literature essentially draws from the earlier works of Nurske and Leibenstein. They argue that there is a certain minimum threshold level (in income, productivity, skill or any such parameters) that a poor person (or society) should achieve in order to move out of the precarious condition that she is in. Unless that threshold is crossed, all the changes will be futile. The person will fall back to his initial position.

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[9] The formulation assumes weak positive and strong negative mobility. It could be appropriately modified for strong positive and weak negative mobility.

[10] This specific form follows from the form of **M-MO.** Changing it will change it.

[11] W e cannot explicitly state perfect mobility or immobility here. Since it is a net measure, the effect depends on the relative strength of the positive and negative components of the measure.

[12] See our arguments as given before.

Clearly then, to have meaningful impact, it is not enough to have mobility but mobility above some minimum threshold.

The third argument is from the vulnerability standpoint. Vulnerability theorists differentiate between static and dynamic issues of deprivation. Poverty measures deprivation from a static viewpoint. However the fact that a family in rural Ethiopia has been found to be above poverty in a certain does not signify that this family have escaped the clutches of deprivation. In any subsequent years, if the situation becomes slightly unfavourable (crop failure, political or social upheavals, food scarcity etc.) can revert the family back to the poverty level or even below that. Thus even without the threshold, unless the partial mobility rate should be above a certain minimum level to make the family less vulnerable.

The second and third issues constitute what is called *sustainable* partial mobility. A sustainable partial mobility may be defined as a mobility rate that is sufficient enough to enable the unit to maintain its new position or at least reduce the risk of reverting back to the original position.

These two issues-perception and sustainability brings in certain lumpiness within the concept of fractional mobility. This issue of lumpiness was not considered by Sengupta and Ghosh (2010). In this paper we sought to include this issue within the frame work of partial mobility developed earlier.

In short, to have meaningful discussion about the dynamics of human development, concentration should be directed towards analyzing mobility in terms of the magnitude of mobility. A movement with some specified magnitude is defined as a **fractional mobility.**

For each of the partial mobility indices defined above there will be a number of fractional mobility indices. A fractional mobility may be of different dimensions. A first-dimensional fractional mobility is the partial movement to the immediate groups or classes. Further movements are captured by higher dimensional fractional mobility. Fractional mobility can be positive, negative or net. We first consider the positive fractional mobility.

In order to derive the (positive) fractional mobility, we first introduce the axiomatic structure that is necessary for its erection. The **NO** axiom is still valid here. However the monotonocity axiom is now remodeled as **Fractional Monotonicity** (**FMO**):

(A.2)//// **Fractional Monotonocity (FMO)**: **FMO** will imply M(P)>M(P*) if any of the two axioms are true (i) $p_{ij} \geq p_{ij}^{*}$ for all $i = j + s$ and (ii) $p_{ij} = p_{ij}^{*}$ for some $i = j + s$, where the dimension of fractional mobility is $s\ (= i+1, i+2, \ldots\ldots, i+s)$ and $(i+s) \leq k$.

FMO indicates that for monotonicity we concentrate only the particular row and the dimension of fractional mobility we are concerned with. Ideally then a rise in at least one of the non-diagonal p_{ij} for that row within that dimension should increase the fractional mobility.

$$\text{Define: } \mathbf{T^{ex1}}= \begin{pmatrix} 0.4 & 0.4 & 0.2 \\ 0.4 & 0.3 & 0.3 \\ 0.2 & 0.3 & 0.5 \end{pmatrix},\ \mathbf{T^{ex2}}= \begin{pmatrix} 0.5 & 0.4 & 0.1 \\ 0.5 & 0.1 & 0.4 \\ 0 & 0.5 & 0.5 \end{pmatrix}$$

In our example of T^{ex1} above it is clear that if we consider fractional mobility of one-dimension:

$$\text{(i)}\ \ M^1_{+1}(T^{ex1}) = M^1_{+1}(T^{ex2})$$

though if we consider fractional mobility index of dimension-2, we have:

$$\text{(ii)}\ \ M^1_{+2}(T^{ex1}) > M^1_{+2}(T^{ex2})$$

We now consider the next axiom of immobility. As above, though the positive fractional mobility of dimension s ($M^i_{+s}(P)$) satisfies both **I** and **EI**, they are unnecessarily strict. Rather we modify **EPI** to **FPI** for our purpose:

(A. 3)//// **Fractional Partial Immobility (FPI):** $M^i_{+s}(P)$ =0 when there is zero probability for any observations (belonging to the i th row) to move to any higher cell within the dimension s. **FPI** ensures that $p_{i/j}\forall j > i^{/} = 0$, with $i = j + s$, where the dimension of fractional mobility is s $(= i+1, i+2, \ldots\ldots, i+s)$ and $(i+s) \le k$.

Similarly for perfect immobility we get a new modified axiom:

(A. 4)//// **Fractional Perfect Mobility (FPM)**: $M^i_{+s}(P)$ =1 when there is a unit probability for any observations (belonging to the i th row) to move to any of the higher cell within the dimension. **FPM** ensures that $p_{i/j}\forall j > i^{/} = 1$, with $i = j + s$, where the dimension of fractional mobility is s $(= i+1, i+2, \ldots\ldots, i+s)$ and $(i+s) \le k$ [13].

We can now define positive fractional mobility of s-dimension as follows:

$$M^i_{+s}(P) = f(p_{i^{/}j} \,|\, i = i^{'} \,\&\, i = j) = \sum_{j=i^{/}+1}^{i^{'}+s} (p_{i^{/}j})^{\alpha} \qquad (4)$$

This fractional mobility index satisfy the assumptions of **NO, FMO, FPI** and **FPM** if α=1**.** As for partial mobility, this is a strict version of fractional mobility. A weaker version is possible if we consider fractional mobility of zero dimension.

We now state the axiomatic structure for the negative fractional mobility ($M^i_{-s}(P)$). **NO** is still true here. However monotonicity is now modified:

(A.2)^{v} **Fractional Negative monotonocity axiom** (**FNMO**): **FNMO** will imply M(P)>M(P*) if the following relations are true (i) $p_{ij} \le p^*_{ij}$ for all $i > j$ and (ii) $p_{ij} = p^*_{ij}$ for some $i > j$ for some $i = j - s$, where the dimension of fractional mobility is s $(= i-1, i-2, \ldots\ldots, i-s)$ and $(i-s) \ge 0$.

In our example of T^{ex1} above it is clear that if we consider negative fractional mobility of one-dimension:

$$\text{(i)}\ \ M^3_{-1}(T^{ex1}) > M^3_{-1}(T^{ex2})$$

and if we consider fractional mobility index of dimension-2, we have:

$$\text{(ii)}\ \ M^3_{-2}(T^{ex1}) > M^3_{-2}(T^{ex2})$$

[13] This certainly means that **FPM** seems to imply total indifference to what happens to the various probabilities of upward mobility outside the dimension.

Similarly, we now modify both **FPI** and **FPM**.

(A.3)[v] **Fractional Partial Negative Immobility (FPNI):** $M^i(P)=0$ when there is zero probability for any observations (belonging to the *i* th row) to move to any lower cell within the dimension. **EPM** ensures that $p_{i'j}\forall j < i' = 0$ for some $i = j - s$, where the dimension of fractional mobility is $s\ (= i-1, i-2, \ldots\ldots, i-s)$ and $(i-s) \geq 0$.

As with positive mobility, this axiom logical leads to the perfect mobility axiom from the negative side- Fractional Perfect Negative Mobility (**FPNM**).

(A.4)[v] **Fractional Perfect Negative Mobility (EPNM)**: $M^i(P)=1$ when there is a unit probability for any observations (belonging to the *i* th row) to move to any of the lower cell within the dimension. **EPNM** ensures that $p_{i'j}\forall j < i' = 1$ [14] for some $i = j - s$, where the dimension of fractional mobility is $s\ (= i-1, i-2, \ldots\ldots, i-s)$ and $(i-s) \geq 0$.

We can now define positive fractional mobility of s-dimension as follows:

$$M^i_{-s}(P) = f(p_{i'j} \,|\, i = i' \ \&\ i = j) = \sum_{j=i'-1}^{i'-s} (p_{i'j})^{\alpha} \tag{5}$$

This fractional mobility index satisfy the assumptions of **NO, FNMO, FPNI** and **FPNM** if α=1**.** As for partial mobility, this is a strict version of fractional mobility. A weaker version is possible if we consider fractional mobility of zero dimensions.

As for partial mobility, this is a strict version of fractional mobility. A weaker version is possible if we consider fractional mobility of zero dimensions.

Next we consider the Net Fractional Mobility ($NM^i_s(P)$). As in the case of partial mobility, this index measures the strength of pull and push factors within the dimensions of fractional indices.

The fractional net mobility index satisfies **M-NO** but the **N-MO** should be modified. It may be restated as:

(A.2)[v] **Modified Monotonicity (M-MO): M-MO** implies[15] M(P)>M(P*) if at least one of the relations are true:

(i) $p_{ij} \geq p^*_{ij}$ for all $i < j$ and $p_{ij} = p^*_{ij}$ for some $i \neq j$ with $i = j + s$**,** where the dimension of fractional mobility is $s\ (= i+1, i+2, \ldots\ldots, i+s)$ and $(i+s) \leq k$

(ii) $p_{ij} \leq p^*_{ij}$ for all $i \geq j$ and $p_{ij} = p^*_{ij}$ for some $i \neq j$ for some $i = j - s$**,** where the dimension of fractional mobility is $s\ (= i-1, i-2, \ldots\ldots, i-s)$ and $(i-s) \geq 0$.

Thus the partial net mobility index satisfying **M-MO** turns out to be[16]: $M^i(P) = f(p_{ij} \,|\, i < j) - g(p_{ij} \,|\, i \geq j)$.

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[14] This certainly means that **EPNM** seems to imply total indifference to what happens to the various probabilities of downward mobility. An introduction of such a preference pattern will necessitate the concept of weighted partial mobility indices. We refrain from such an exercise in this paper.

[15] The formulation assumes weak positive and strong negative mobility. It could be appropriately modified for strong positive and weak negative mobility.

We are now in a position to define net fractional mobility indices[17] $NM^{i}_{s_1 s_2}(P)$ as follows:

$$\mathrm{NM}^{i}_{s_1 s_2} = M^{i}_{+s_1}(P) - M^{i}_{-s_2}(P) \tag{6}$$

This measure satisfies both **M-NO** and **M-MO.** It can be both symmetric ($s_1 = s_2$) and asymmetric ($s_1 \neq s_2$)

4. Global experience of partial and fractional mobility

The measures developed above are readily applicable to the world data on human development. Such data are available from the website of United Nation Development Programme (UNDP)[18]. We have selected a time span of ten years covering three time points: 1997, 2002, 202007[19]. These points are selected only to capture the era of globalization and integration of world economy.

We have selected three dimension of human development-Education Index (EI), Gross Domestic Product Index (GDP Index) and Life Expectancy Index (LE Index) together with the Human Development Index (HDI). Our analysis is given in the Table1 to Table 4[20]. Relative mobility table is provided in the Appendix (Table A1 to Table A4). In the original UNDP figure (Human Development Report 2009) the countries were divided into four categories: Very High Human Development, High Human Development, Medium Human Development and Low Human Development. The same classification is maintained in the categorization of the mobility matrix. This would help to remove some of the ambiguity regarding the discrete classification in mobility matrix.

There are numerous debates regarding the long run performance in the global scenario. Our analysis however being partial does not give any unilateral picture. Considering partial mobility, we see a clear improvement in the partial mobility of Rawlsian class in the two separate time points regarding all the parameters of human development. However, net mobility though decreasing is still negative for these countries. As to the elitist category, there is a mix picture, while under education there is some deterioration; there is a clear improvement for GDP index and all other parameters. In short, the benefit of globalisation is reaching at a very slow rate to all the Rawlsian (poorest).

The analysis of fractional mobility reveals a more succinct picture. The fractional mobility indices are cumulative in nature. The dimension represents the number of classes the particular group has the possibility to traverse[21]. It is seen that for the Rawlsian group, probability of moving beyond the immediate class is zero. Thus though there might be some

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[16] This specific form follows from the form of **M-MO.** Changing it will change it.

[17] W e cannot explicitly state perfect mobility or immobility here. Since it is a net measure, the effect depends on the relative strength of the positive and negative components of the measure.

[18] http://hdr.undp.org/en/reports/

[19] Three Human Development Reports of the year of 1999, 2004 and 2009 respectively for the mentioned time periods.

[20] The calculation of partial mobility is given in Sengupta and Ghosh (2010).

[21] The calculation is same as that of partial mobility. However here we consider only a sub-group of the classes instead of all the classes as under the partial mobility.

mobility for the Rawlsian class, it is very weak. None of the Rawlsian countries could move from "very poor" to "rich" or even the "moderate category".

HDI (Rawlsian)	Strict Positive Mobility				
	Frac. (Dim-0)	Frac. (Dim-1)	Frac. (Dim-2)	Frac. (Dim-3)	Partial
1997-2002	NA	0.15	0.15	0.15	0.15
2002-2007	NA	0.39	0.39	0.39	0.39
1997-2007	NA	0.41	0.41	0.41	0.41
HDI (Elitist)	Weak Positive Mobility				
1997-2002	1	NA	NA	NA	1
2002-2007	1	NA	NA	NA	1
1997-2007	1	NA	NA	NA	1
HDI (Rawlsian)	Weak Negative Mobility				
1997-2002	0.85	NA	NA	NA	0.85
2002-2007	0.61	NA	NA	NA	0.61
1997-2007	0.59	NA	NA	NA	0.59
HDI (Elitist)	Strict Negative Mobility				
1997-2002	NA	0	0	0	0
2002-2007	NA	0	0	0	0
1997-2007	NA	0	0	0	0
HDI (Rawlsian)	Net Mobility				
1997-2002	-0.85	-0.85	-0.85	-0.85	-0.85
2002-2007	-0.61	-0.61	-0.61	-0.61	-0.61
1997-2007	-0.59	-0.59	-0.59	-0.59	-0.59
HDI (Elitist)	Net Mobility				
1997-2002	1	1	1	1	1
2002-2007	1	1	1	1	1
1997-2007	1	1	1	1	1

Note: Frac. implies Fraction; NA implies Not Applicable, Dim implies Dimension.
Source: Authors' calculation

Table 1. Partial and Fractional Mobility for Human Development Index

Interestingly, almost all of the Rawlsian countries belong to Africa (See Table of Appendix A5). Most of these countries remain at the Rawlsian level throughout the time span. On the contrary, all the elitist countries belong to the industrialised developed countries including some non European countries (such as Japan and Australia). In short, even after the phenomenal expansion of the world economy, the polarisation is still prominent. What may be the cause of this persistence?

In this respect, we may focus on the debate on "poverty culture" recently rejuvenated by Karelis (2007). In this "controversial" book, he looks at the consequences of poverty that go well beyond the normal quantitative analysis. He argues that the "economics of Well-off can't help the poor". Remaining under sustained poverty for a long time infringes upon on the psychological domain of the poor. Poverty arises not from having something less than others but from failure from full participation in the fruits of the society (Karelis 2007). Such exclusion results in the dysfunctional personality in the individual variously termed as

apathy, the fragmented self and *akrasia*- the weakness of will or atypical preferences. It generates peculiar and "non-rational" behavior of the poor. These activities are, in general, harmful to the long –run interest of the poor. Yet these activities are undertaken for temporary "relief".

EI (Rawlsian)	Strict Positive Mobility				
	Frac. (Dim-0)	Frac. (Dim-1)	Frac. (Dim-2)	Frac. (Dim-3)	Partial
1997-02	NA	0.19	0.19	0.19	0.19
2002-2007	NA	0.43	0.43	0.43	0.43
1997-2007	NA	0.52	0.52	0.52	0.52
EI (Elitist)	Weak Positive Mobility				
1997-2002	1.00	NA	NA	NA	1.00
2002-2007	0.94	NA	NA	NA	0.94
1997-2007	0.97	NA	NA	NA	0.97
EI (Rawlsian)	Weak Negative Mobility				
1997-2002	0.81	NA	NA	NA	0.81
2002-2007	0.57	NA	NA	NA	0.57
1997-2007	0.48	NA	NA	NA	0.48
EI (Elitist)	Strict Negative Mobility				
1997-2002	NA	0	0	0	0
2002-2007	NA	0.06	0.06	0.06	0.06
1997-2007	NA	0.03	0.03	0.03	0.03
EI (Rawlsian)	Net Mobility				
1997-2002	-0.81	-0.81	-0.81	-0.81	-0.81
2002-2007	-0.57	-0.57	-0.57	-0.57	-0.57
1997-2007	-0.48	-0.48	-0.48	-0.48	-0.48
EI (Elitist)	Net Mobility				
1997-2002	1	1	1	1	1
2002-2007	0.94	0.88	0.88	0.88	0.88
1997-2007	0.97	0.94	0.94	0.94	0.94

Source: Authors' calculation

Table 2. Partial and Fractional Mobility for Education Index (EI)

Such a phenomenon may well transmit to the analysis of the countries. A poor country may find it more prudent to get short-run relief enhancing activities rather than pursuing a more sustained long-run growth. Faced by limited opportunities and very little prospect of moving out of the vicious circle of poverty in the foreseeable future, these nations undertake activities that are detrimental to their own long run interest. A sort of poverty culture develops that fasten these poor countries to the low point they are in.

LEI (Rawlsian)	Strict Positive Mobility				
	Frac. (Dim-0)	Frac. (Dim-1)	Frac. (Dim-2)	Frac. (Dim-3)	Partial
1997-2002	NA	0.08	0.08	0.08	0.08
2002-2007	NA	0.32	0.32	0.32	0.32
1997-2007	NA	0.37	0.37	0.37	0.37
LEI (Elitist)	Weak Positive Mobility				
1997-2002	1	NA	NA	NA	1
2002-2007	1	NA	NA	NA	1
1997-2007	1	NA	NA	NA	1
LEI (Rawlsian)	Weak negative Mobility				
1997-2002	0.92	0.92	0.92	0.92	0.92
2002-2007	0.68	0.68	0.68	0.68	0.68
1997-2007	0.63	0.63	0.63	0.63	0.63
LEI (Elitist)	Strict negative Mobility				
1997-2002	NA	0	0	0	0
2002-2007	NA	0	0	0	0
1997-2007	NA	0	0	0	0
LEI (Rawlsian)	Net Mobility				
1997-2002	-0.92	-0.92	-0.92	-0.92	-0.92
2002-2007	-0.68	-0.68	-0.68	-0.68	-0.68
1997-2007	-0.63	-0.63	-0.63	-0.63	-0.63
LEI (Elitist)	Net Mobility				
1997-2002	1	1	1	1	1
2002-2007	1	1	1	1	1
1997-2007	1	1	1	1	1

Source: Authors' calculation

Table 3. Partial and Fractional Mobility for Life Expectancy Index (LEI)

GDPI (Rawlsian)	Strict Positive Mobility				
	Frac (Dim-0)	Frac (Dim-1)	Frac (Dim-2)	Frac (Dim-3)	Partial
1997-2002	NA	0.19	0.19	0.21	0.21
2002-2007	NA	0.25	0.25	0.25	0.25
1997-2007	NA	0.31	0.31	0.33	0.33
GDPI (Elitist)	Weak Positive Mobility				
1997-2002	0.82	NA	NA	NA	0.82
2002-2007	1	NA	NA	NA	1
1997-2007	1	NA	NA	NA	1
GDPI (Rawlsian)	Weak Negative Mobility				
1997-2002	0.79	NA	NA	NA	0.92
2002-2007	0.75	NA	NA	NA	0.68
1997-2007	0.67	NA	NA	NA	0.63
GDPI (Elitist)	strict Negative Mobility				
1997-2002	NA	0.18	0	0	0.18
2002-2007	NA	0	0	0	0
1997-2007	NA	0	0	0	0
GDPI (Rawlsian)	Net Mobility				
1997-2002	-0.79	-0.79	-0.79	-0.79	-0.79
2002-2007	-0.75	-0.75	-0.75	-0.75	-0.75
1997-2007	-0.67	-0.67	-0.67	-0.67	-0.67
GDPI (Elitist)	Net Mobility				
1997-2002	0.82	0.64	0.64	0.64	0.64
2002-2007	1	1	1	1	1
1997-2007	1	1	1	1	1

Source: Authors' calculation

Table 4. Partial and Fractional Mobility for Gross Production Index (GDPI)

5. Social dimensions in fractional mobility

Frequently, we see in the social fields, changes that are partial. For example, in an otherwise poor tribal society, women have greater freedom than the males. This is a dilemma that the policy makers face when dealing with social phenomenon. In India, for example, the so-called "dalits" includes the tribes that are given special privilege by the constitution. They are deemed as Scheduled Tribes (ST). This section of populace is seriously impoverished (as revealed by the government data). For example, according to the literacy rate in India, is lower for the Scheduled Tribes. However, the gender ratio is higher for the ST as compared to the general population. Thus though, this section is backward in many respects, there is far less discrimination regarding the gender discrimination. In fact, in some tribal societies, matrilineal pattern exist that gives substantial preference to women. However these women are victims of upper caste people. Thus the tribal women are peculiarly placed. They are partially empowered There is thus a partial improvement-the empowerment of women within the community. A fractional movement would help us to understand the dimensions of this partial empowerment in a changing world. As these people become developed, the dominant patrilineal pattern emerges that is imminent from a deterioration gender ratio over time.

6. Conclusion

This chapter attempts to bring in the partial changes that may be different from an overall or aggregate change. A new concept of fractional mobility is developed for this purpose. The analysis is then extended to the World data covering country specific data. It reveals that even after the phenomenal expansion of the world economy, the polarisation is still prominent. A "poverty culture" is then seen to develop that dampen the recovery prospect of the poor Rawlsian economies. A social example of partial and fractional mobility is provided.

7. Appendix

(a) 1997-2002 Number of Countries	Upper end point			
	0.5	0.8	0.9	1
34	0.85	0.15	0.00	0.00
90	0.04	0.84	0.11	0.00
27	0.00	0.04	0.70	0.26
18	0.00	0.00	0.00	1.00
(b) 2002-202007 Number of Countries	0.5	0.8	0.9	1
33	0.61	0.39	0.00	0.00
82	0.00	0.72	0.28	0.00
29	0.00	0.00	0.62	0.38
25	0.00	0.00	0.00	1.00
(c) 1997-202007 Number of Countries	0.5	0.8	0.9	1
34	0.59	0.41	0.00	0.00
90	0.00	0.64	0.36	0.00
27	0.00	0.00	0.33	0.67
18	0.00	0.00	0.00	1.00

Source: Authors' calculation

Table A1. Inter countries relative HDI dynamics, 1997, 2002 and 202007 first order transition matrix, time stationary.

(a) 1997-2002 Number of Countries	Upper end point			
	0.5	0.8	0.9	1
27	0.81	0.19	0.00	0.00
54	0.02	0.76	0.22	0.00
49	0.00	0.0816	0.7347	0.1837
39	0.00	0.00	0.00	1.00
(b) 2002-202007 Number of Countries	0.5	0.8	0.9	1
23	0.57	0.43	0.00	0.00
50	0.00	0.76	0.22	0.02
48	0.00	0.00	0.79	0.21
48	0.00	0.00	0.06	0.94
(c) 1997-202007 Number of Countries	0.5	0.8	0.9	1
27	0.48	0.52	0.00	0.00
54	0.00	0.63	0.35	0.02
49	0.00	0.00	0.65	0.35
39	0.00	0.00	0.03	0.97

Source: Authors' calculation

Table A2. Inter countries relative Education Index dynamics, 1997, 2002 and 202007 first order transition matrix, time stationary.

(a) 1997-2002 Number of Countries	Upper end point			
	0.5	0.8	0.9	1
38	0.92	0.08	0.00	0.00
88	0.03	0.82	0.15	0.00
42	0.00	0.2007	0.86	0.2007
1	0.00	0.00	0.00	1.00
(b) 2002-202007 Number of Countries	0.5	0.8	0.9	1
38	0.68	0.32	0.00	0.00
78	0.00	0.78	0.22	0.00
49	0.00	0.10	0.43	0.47
4	0.00	0.00	0.00	1.00
(c) 1997-202007 Number of Countries	0.5	0.8	0.9	1
38	0.63	0.37	0.00	0.00
88	0.023	0.705	0.261	0.011
42	0.000	0.048	0.357	0.595
1	0.00	0.00	0.00	1.00

Source: Authors' calculation

Table A3. Inter countries relative Life Expectancy Index dynamics, 1997, 2002 and 202007 first order transition matrix, time stationary.

(a) 1997-2002 Number of Countries	Upper end point			
	0.5	0.8	0.9	1
52	0.79	0.19	0.00	0.02
81	0.04	0.86	0.10	0.00
25	0.00	0.04	0.48	0.48
11	0.00	0.00	0.18	0.82
(b) 2002-202007 Number of Countries	0.5	0.8	0.9	1
44	0.75	0.25	0.00	0.00
81	0.05	0.72	0.22	0.01
22	0.00	0.00	0.23	0.77
22	0.00	0.00	0.00	1.00
(c) 1997-2007 Number of Countries	0.5	0.8	0.9	1
52	0.67	0.31	0.00	0.02
81	0.025	0.654	0.259	0.062
25	0.00	0.00	0.08	0.92
11	0.00	0.00	0.00	1.00

Source: Authors' calculation

Table A4. Inter countries relative Gross Domestic Production Index dynamics, 1997, 2002 and 202007 first order transition matrix, time stationary.

Rawlsian Countries	Elitist Countries
Niger, Sierra Leone, Central African Republic, Mali, Burkina Faso, Congo (Democratic Republic of the), Chad, Burundi, Guinea-Bissau, Mozambique, Ethiopia, Guinea, Rwanda, Senegal, Eritrea, Zambia, Côte d'Ivoire, Benin, Malawi,Togo	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Japan, Luxembourg, Netherlands, New Zealand, Norway, Sweeden, Switzerland, United Kingdom, United States

Table A5. Consistent Rawlsian and Elitist countries over the three time periods

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5

Does Environmental Degradation Affect Human Development and Sustainable Economic Development? Case of Pakistan

Shaista Alam
Applied Economics Research Centre
University of Karachi
Pakistan

1. Introduction

The concepts of human development and sustainable economic development seem to be intercorrelated and highly debatable issue in the recent literature. Human development can play an imperative role in economic development of a country. As Solow (1956) showed in the neoclassical growth model that human development is both the result of economic growth and is also an input to it. Thus, human capital acquires profound importance in determining the level of economic growth with respect to education, health and nutrition in the work of Lewis (1955) and then also in modern endogenous growth theories. Torras and Boyce (1998) as well as Klick (2002) include measures of human development as control variables in their respective setup.

Economic growth is associated with negative externalities, for example environmental degradation, while Economic Development is an increase in the real income per capita as well as improvements in a variety of indicators such as literacy rates, life expectancy, welfare of the nation, quality of life and quality of environment. Economic development is however concerned with sustainability which means meeting the present needs without compromising future needs. Sustainable development may be defined as continuous increase in the socio-economic standard of living of a country's population, normally accomplished by increasing its stocks of physical and human capital and improving its technology and environment. To ensure the sustainable development of the economy environmental degradation should not increase with time but be reduced or at least remain constant. If it increases, the economy will move further away from sustainability, while if it decreases, the economy will move closer towards it.

The rapidity of modernization, urbanization, and industrialization has led to serious environmental concerns in the developing countries like Pakistan. Over the past few decades, the natural resources have depleted remarkably resulting from accelerated pace of economic and social transformation. Economic and social changes such as large increase in population, shift of population from rural to urban areas, increase in mechanized and chemical agriculture, industrial production, capital accumulation, and innovative technologies have transformed the country’s natural resource base, both as a source of

factor inputs and as a by product of pollution associated with economic activity. The continuously accelerated and unabated environmental degradation in the country is dangerous for sustainability of human development that is the foundation for long-term economic development. Economic development and human development efforts are increasingly constrained by environmental concerns, including degradation of forests and fisheries, lack of fresh water resources, and poor human health as a result of air and water pollution (Banister 1998; Chu and Yu 2002). Intensified crop and livestock production combined with misdirected incentives have contributed to increased production of chemical and organic wastes, natural resource and biodiversity loss, and soil erosion. Lack of an adequate supply of clean water, the explosive growth in population, and the artificial methods of cultivation are the most severe environmental problem in many developing countries.

The present study empirically investigates the long run rapports of environmental degradation and major socio-economic and demographic factors such as poverty, urbanization, trade liberalization, increasing population and economic growth on quality of human development in Pakistan. The study further estimates the effects of environmental degradation and other socio-economic and demographic factors as mentioned on sustainability of economic development in the country. Such analytical endeavor is necessary for disentangle an effective and efficient macroeconomic policy framework to prepare long term strategies for sustainability of economic development and high quality of human development in Pakistan particularly and generally in developing countries. The organization of the chapter is as: section II discusses the factor affecting human development as well as economic development, section III presents theoretical framework, section IV demonstrates the econometric techniques to be employed, section V discusses data sources and variables information and section VI explains the empirical analysis. Finally section VII presents conclusions and policy recommendations.

2. Human development and economic development with environmental concern

The eventual purpose of economic activities is improvement in quality of human recourse development and the principal aim of economic growth is the welfare of human beings. Most countries emphasize social well-being of people as the fundamental goal. Consequently, the problem faced by the policy makers is to increase social benefits. However, it is not clear whether the indicators of economic progress and measures of wealth such as growth in income per capita are the primary determinant of social and economic well being of the masses. Growth in income per capita may be insufficient for human development and increasing social benefits. Mazumdar (1996) estimated the causal relation between human development and economic growth and concluded that there is no uniform relation. The quality of human capital can be poor even with rapid economic growth. In fact, the transformation of economic growth to human development depends on several factors (Costantini, 2006).

2.1 Poverty

Poverty is a major cause of poor quality of human development as well as a big hurdle to achieving sustainable economic development. Whether defined by income, socioeconomic

status, living conditions or educational level, poverty is the single largest determinant of human development and poor economic growth (Borooah, 2005; Baulch and Hoddinott, 2000). Living in poverty is associated with poor sanitary conditions, unabated sewerage system, lack of clean water resources, and increased exposure to environmental risks. Urban poverty is a challenge in all developing countries, where not only the number of urban poor is increasing, but also the divisions among social groups within cities. There is also evidence that rural households use environmental resources quite extensively (Sale 1981).

The poor are traditionally taken as the agents for causing society's many problems. The most recent allegation directed against them is that they cause environmental degradation. For example, in one of the conclusions of the Bruntland commission report, which incidentally has been accepted as the proposal for environmental conservation, it is explicitly stated that poverty is a major cause of environmental problems and amelioration of poverty is a necessary and central condition of any effective program to deal with environmental concerns. Jalal (1993), argued that "It is generally accepted that environmental degradation, rapid population growth and stagnant production are closely linked with the fast spread of acute poverty in many countries of Asia". Both poverty and environmental degradation have been increasing in many developing countries. Ethnic minorities, migrants and refugees are the sources of environmental degradation. Their needs often receive far less attention, and they cannot always be reached through the usual hygienic and welfare channels. This problem is increasing in many developing countries, including Pakistan.

2.2 Population

Rapidly increasing population is one of the main obstacles in the way of sustainable economic development as well as human development. Specialists have raised concerns that the ever growing world population will be an obstacle to all people being able to benefit from human development, and therefore argue that further measures are needed to ease this "population explosion". "If we could slow our population growth rate, we would have an easier job in dealing with all the other things like education, health, employment, housing, food, the environment and so on"[1]. Others have however criticized this approach, pointing to the need to rather focus on ways to improve the life quality of the world population as a whole.

Research relating to the theme of population and human development during the past one year has largely explored the shades of the experience of human development in the condition on the one hand, and issues of access and inequity in health and education, on the other. While health, nutrition and education have been the prime areas of concern within the human development perspective, there have also been attempts to explore the issue across diverse population groups, to examine private-public provisions, and to make a gender-sensitive evaluation. Regarding health, the contribution of research has been more towards understanding inequities in access, and in the utilization of health care under varying scenarios, and reflecting on their consequences.

[1] Professor Eric Tayag of the Department of Health in the Philippines (http://www.eurostep.org/wcm/archive-eurostep-weekly/1790-population-growth-raises-concerns-over-human-development.html)

Professionals have exclusively highlighted the need to improve reproductive health conditions and female education, as a means to improve the life quality of women particularly and in general the overall population as a whole. Female education and reproductive health services are the two factors that will bring down unsustainable population growth[2].

2.3 Urbanization

Another major determinant of economic development as well as human resource development is urbanization, the share of urban population in total population. The rate of urbanization and its attendant impacts differ in regions across the globe. Asia contains almost half the world's mega cities and continues to urbanize rapidly. Given its current annual growth rate, Asia's urban population is expected to double in less than 20 years. Urbanizations reflect more than demographic change. It is both driven by and profoundly influences the context and processes of development. It exerts both direct and indirect advantages in the struggle towards global sustainability and human development. The origins of many global environmental problems related to air and water pollution are located in cities (Reddy, 2004). Cole and Neumayer (2004) argued that means of transports, like cars, buses, etc., are more intensively used in urban areas as compared to rural parts of the economy. Moreover food and other consumer goods have to be transported into cities, which again should lead to higher pollution that affect human health. The other sources of water pollution come from various other different situations which tend to occur in urban areas. For example, soil particles from construction and demolition sites, and also oil and toxic chemicals from car maintenance and runoff from road surfaces (Environmental Agency 2005) are also causes of water pollution. In addition, land in urban cities is covered with 'buildings, asphalt, and concrete', which brings a large amount of quick runoff, contributing to water pollution (Miller 1996; Stapleton et al 2004). Such an urban lifestyle and an urban design are also factors contributing to water pollution. However, much of the sewage in urban areas goes untreated and is dumped into rivers and lakes. As a result, surface water and ground water have been increasingly polluted (Banister 1998).

In urban areas, education facilities are batter than rural areas, in this case urbanization affect human development positively. Qiang (2009) estimated that urbanization in China plays the roles not only for improving human capital but also for controlling over population growth. Cao and Lutz (2004) proved that urbanization and education are linked directly to one another. Currently, in the developing countries like Pakistan there are many contrasts occur in the urban areas. They contribute to human development - as well as constrain it. They are centers of affluence - as well as concentrations of poverty. They bring out the best in human enterprise - as well as the worst in human greed. They contain some of the best social services available in the country. But they are also host to many social ills - overcrowding, unsanitary living conditions, drug addiction, alienation, social unrest and environmental pollution.

There is a strong, positive link between urbanization and levels of human development. Urban population, in both highly industrialized countries (HIC) and those countries with a

[2] Professor Wolfgang Lutz who convened a panel on population, development and environment in September 2011.

high Human Development Index (HDI1), is above 70 percent. Urbanization falls to less than 30 percent in countries that are classified as Least Developed Countries (LDC) or have a low HDI. All HICs score high in their provision of urban services and infrastructure to all citizens and low in incidence of absolute poverty. Development and urbanization, thus, proceed hand in glove. Without substantial investment in the infrastructure and services that support both, neither can occur (UNDP, Human Development Report 2000). The growing concentration of people in cities is by now almost exclusively a developing country phenomenon. The urban population of the developing countries, now 1.3 billion, is expected to grow by nearly another billion in the next 15 years. According to recent UN projections, the developing world's rural population will reach an upper limit by 2015 and beyond this point all future population growth will be concentrated in urban areas. By 2015 half the developing world's people will live in urban areas (UNDP, Human Development Report 2009).

2.4 Globalization

In general, globalization can affect the environment through trade liberalization by several channels, such as trade affects the overall *scale* of the economy; the *techniques* of production, and *composition* of industries (Copeland and Taylor, 2003). The most direct effect of trade liberalization on the environment would be through the composition of industries and hence much of the focus of the literature has been on dissecting the composition effects of trade. Trade liberalization leads to specialization, and countries that specialize in less (more) pollution-intensive goods will have cleaner (dirtier) environments. This discussion suggests that developing countries may be able to achieve high levels of economic growth and high levels of environmental performance long before they reach the income levels of the industrialized countries. This is not to say that there are no trade off between growth and the environment. Even with good environmental policies and clean technologies, continued increases in output may tend to increase the total volumes of various kinds of pollutants in many cases. Every society has to decide for itself on the relative value it places on economic output and the environment. The point about international openness, though, is that in general it appears to make this tradeoff less painful for developing countries, allowing more environmental protection for the same amount of growth, or more growth for the same amount of environmental protection.

In any case while trade does offer opportunities to improve the standard of living of people greater participation in trade does not necessary translates in accelerated human development. It is interesting to know how globalization has influenced our day to day life - if I will be more specific - the quality of life. There are contradictory views though on this issue. While the cohorts of globalization theory view globalization as improving economic growth and quality of life indicators, the critics view globalization as accentuating inequalities, promoting poverty, and degrading the over all quality of human life. Running through this contentious debate, the present research examines how economic and cultural globalizations have influenced the overall quality of life, or in the language of developmental economists, how globalization has influenced the indicators that constitute human development. Globalization has a major impact on the human resource development in developing countries (Qian, 2009). It has led to homogenization and convergence in organization strategies, structures and processes as well as in consumer choice. With accelerating globalization, organizations have had to change and new trends have set in even in the development of human resources. Globalization has led to

changes in organization design and organization structures are leaner thus improving efficiency but having a negative impact on staff numbers which have had to be reduced. This means employees have been economized in many sectors in order for those organizations to gain competitive advantage. Although the homogeneity that results from globalization has had a major effect in developing countries because of brain drain. Globalization can therefore be said to have had an exceptional impact on a developing economy (Hallak and Levinsohn, 2004).

3. Theoretical framework

The study intends to analyze the factors influencing the human development and economic development as well as environment through vector autoregressive framework. For this purpose the study used human development index collected from United Nations database. Based on the preceding discussion, the theoretical framework for this empirical study is set as follows:

If *HD* is human development, *EG* is the economic growth measured as per capita GDP, *PV* represents poverty, *URB* is the rate of urbanization**,** *GL* represents globalization measured as export plus import to GDP ratio and *PD* is population density. *ED* is environmental degradation in term of water pollution, According to European Environmental Agency "biochemical oxygen demand (BOD) is a measure of how much dissolved oxygen is being consumed as microbes break down organic matter. A high demand therefore can indicate that levels of dissolved oxygen are falling with potentially dangerous implications for the river's biodiversity". According to United Nations Environment Programme, "Emissions of organic water pollutants are measured by biochemical oxygen demand, refers to the amount of oxygen that bacteria in water will consume in breaking down waste". The following relationship can reasonably be expected for human development:

$$HD = f(EG, ED, PV, URB, PD, GL) \tag{1}$$

Expressing the variables in natural logarithms, the base regressions are:

$$lnHD_t = \beta_0 + \beta_1 lnEG_t + \beta_2 lnED_t + \beta_3 lnPV_t + \beta_4 lnURB_t + \beta_5 lnPD_t + \beta_6 lnGL_t + \xi_1 \tag{2}$$

Where, β_1 to β_6 are the elasticities and ξ_1 is the stochastic error term with standard properties.

The expected sign of the coefficient of economic growth β_1 should be positive because economic growth ultimately improves the human welfare (Saxena, 1989). Environmental hazard to the poorest populations vary by human development level. The poor and developing countries tend to face household environmental deficiency such as indoor air pollution and inadequate sanitation and drinking water. These environmental factors lead to wide-ranging risks to human health and education (Human Development Report, 2011). Therefore the coefficient β_2 will be negative. The poverty coefficient β_3 is also negative, because poverty is a major hurdle of human resource development. Population growth and resulting higher population density is often argued to lead to increased stress on water and natural resources, decreased food security, slower human development. So β_5 will be negative. On the basis of above discussion β_4 *and* β_6 would be either positive or negative.

Furthermore, the study extended its empirical analysis to explore the effect of environmental degradation, human development, poverty, globalization, urbanization and

population density on economic growth. To measure economic growth study takes gross domestic product (GDP) per capita at current market price.

$$EG = f(HD, ED, PV, URB, PD, GL) \quad (3)$$

Expressing the variables in natural logarithms, the base regressions are:

$$lnEG = \delta_0 + \delta_1 lnHD_t + \delta_2 lnED_t + \delta_3 lnPV_t + \delta_4 lnURB_t + \delta_5 lnPD_t + \delta_6 lnGL_t + \xi_2 \quad (4)$$

Where δ_1 to δ_6 are the elasticities and ξ_2 is the stochastic error term with standard properties.

The study expects δ1 to be positive because human development can play vital role to achieve economic growth. However, the relationship between environmental degradation and economic development is complex, because the process of economic development is closely related to growth in industrialization and human activities while this growth in industrialization and human activities is clearly the main cause of increase in pollution. Thus limiting this pollution would affect the process of economic growth. Thus one can reasonably expect positive relation δ_2 between the two. The expected sign of δ_3 should be negative because poverty is a major hurdle to continuing economic growth. However, theof δ_4 could be positive or negative. The rapid urbanization induced difficulties for the cities in terms of infrastructure shortage, congestion and pollution control. On the other hand, urbanization might be environmental-friendly. The expected sign of δ_5 may be negative because increased population density can slow the economic growth. The expected sign of δ_6 should be positive because globalization is directly associated with higher economic growth.

Moreover, the study extended its empirical analysis to investigate the effect of economic growth, human development, poverty, urbanization, population density and globalization on environmental degradation.

$$ED = f(EG, HD, PV, URB, PD, GL) \quad (5)$$

Expressing the variables in natural logarithms, the base regressions are:

$$lnED = a_0 + a_1 lnEG_t + a_2 lnHD_t + a_3 lnPV_t + a_4 lnURB_t + a_5 lnPD_t + a_6 lnGL_t + \xi_3 \quad (6)$$

Where, a_1 to a_6 are the elasticities and ξ_3 is the stochastic error terms with standard properties.

In the light of prior discussion, the expected signs of a_1, a_3 and a_5 should be positive. The coefficient of human development a_2 will be positive because increased human development can aware the people to save their environment. While a_4, will be either negative or positive because for urbanization there exist two alternate views. First view argues that increase in urbanization is the main contributor to environmental pollution. For instance, Panayatou (1993) points out environmental degradation tend to firstly increase as the structure of the economy changes from rural to urban, from agricultural to industrial. But second views suggest that urbanization impact environment positively as urbanization involves more efficient use of infrastructure, more efficient use of transportation and more efficient energy use. Whereas a_6 may be positive or negative, because some critics argue that since increased globalization stimulate higher growth in developing countries; this must lead to more industrial pollution and environmental degradation. Moreover, globalization can provide developing countries with both the incentive to adopt, and the access to, advance

technologies, which may provide a cleaner or greener way of producing the good concerned. A World Bank study of steel production in 50 countries found that open economies led closed economies in the adoption of cleaner technologies by wide margins, resulting in the open economies being 17 percent less pollution-intensive in this sector than closed economies (Huq and Wheeler, 1993).

4. Econometric methodology

4.1 Unit root test

The distinction between whether the levels or differences of a series is stationary leads to substantially different conclusions and hence test of non-stationarity that is unit roots are the usual practice today. Engle and Granger (1987), define a non-stationary time series to be integrated of order d if it achieves stationarity after being differentiated d. times. This notion is usually denoted by X t ~I (d). Hence all the series are tested for the probable order of difference stationarity by using the augmented Dickey-Fuller (ADF) tests. ADF test is a standard unit root test, it analyze order of integration of the data series. These statistics are calculated with a constant and a constant plus a time trend; respectively these tests have a null hypothesis of non-stationarity against an alternative of stationarity. ADF test to check the stationarity of the series is based on the equation of the form:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad (7)$$

where εt is a pure white noise error term and ΔYt-1 = (Yt-1 –Yt-2), ΔYt-2 = (Yt-2 –Yt-3) etc. ADF test determines whether the estimates of δ are equal to Zero. Fuller (1976) provided the cumulative distribution of the ADF statistics, if the calculated t-ratio of the coefficient δ is less than the critical value from Fuller table, then Y_t is said to be stationary. (Note that't' ratio of coefficient δ is always with a negative sign). Now, consider for example two series X_t and Y_t both integrated of order (d). Engle and Granger have shown that their linear combination will in general also be I(d). It is an empirical fact that many important macroeconomic variables appear to be integrated of order (d) or I(d) in the terminology of Engle and Granger (1987) so that their changes are stationary. Hence, if the variables are each I(d) than it may be true that any linear combination of these variables will also be I(d). Having established that all the series are integrated of order (d) that is I(d) the study then proceeds to determine the long run behavioral relationships among the variables for the purpose to examine the long run relationship among the variables.

4.2 Testing co-integration using Vector Autoregressive (VAR) approach

The VAR model used is denoted as follows:

$$X_t = \rho_1 X_{t1} + \rho_2 X_{t2} + \ldots\ldots\ldots\ldots + \rho_k X_{t-k} + t + \eta + \mu_t \qquad 1 \le t \le T \qquad (8)$$

Where $\mathbf{X}_t$ is a vector containing *HD*, *EG*, *ED, PV, URB, PD* and *GL* in the model. Starting from the highest possible lag order, and sequentially testing down to the lowest, the optimal lag order is chosen based on AIC and SBC. After running the VAR model and obtaining the most efficient lag order by observing the AIC and SBC values, long run relationship among

the variables have been tested using the Johansen and Juselius (J-J) co-integration technique. Two or more variables are said to be co-integrated if their linear combination is integrated to any order less than'd'. Co-integration test provides the basis for tracing the long-term relationship. The theory of co-integration put forward by Johansen and Juselius (1990) indicate that the maximum likelihood method is more appropriate in a multivariate system. Therefore this study used this method to identify the number of co-integrated vectors in the model. The selection of "r" co-integrating vector is based on the two statistics defined by Johansen as the maximal eigenvalue and the trace statistic. There is "r" or more co-integrating vectors. The Johansen model is given by:

$$\Delta X_t = a_0 + \Pi X_{t-1} + \sum_{i=1}^{k} \theta_i \Delta X_{t-k} + \omega_t \qquad 1 \le t \le T \tag{9}$$

Where $\mathbf{X}_t$ is a column vector of m endogenous variables, Π and θ are $m \times m$ matrices of unknown parameters and t ω is a Gaussian error term. Π can be dichotomized into two $m \times r$ matrices Ω and σ. The reduced rank $r < m$ of Π is hypothesized as H(r): $\Pi = -\Omega\ \sigma T$. The vectors of σ representing the r linear combinations of $\sigma T\ \mathbf{X}_t$ are stationary. The matrix Ω represents the error-correction parameters. To investigate the relationship, two main likelihood ratio tests, also known as the trace test to evaluate the null hypothesis of at most r co-integrating vectors and the maximum eigenvalue test, used to evaluate the null hypothesis of r co-integrating vectors against the alternative of (r+1) co-integrating vectors, are used.

5. Data and variables information

The study is based on annual data covering a time period from 1970 to 2010 for Pakistan. All the time series data of Water Pollution (Organic water pollutant emissions are measured in terms of biochemical oxygen demand –BOD in kilogram per day), gross domestic product (GDP) per capita, population density, urbanization (percentage of urban population from total population) and globalization are compiled from World Development Indicators (WDI 2011). The series of Gini Coefficient, the indicator of poverty is taken from Haroon (2006). The series of human development index is taken from United Nation database (UNDP 2011). All these variables are expressed in natural logarithm.

6. Empirical analysis

6.1 Testing of the unit root hypothesis

A prerequisite in applying the co integration procedure is to test the unit root properties of the data; Table 1 presents statistics describing these properties of the data. For this purpose the present study tested for the existence of a unit root in the level and the first difference of each of the variable under consideration using the well-known Augmented Dickey- Fuller test (ADF test). The summary table of ADF reveals that all variables are non-stationary until being differentiated with the first order.

6.2 Multi-variate co-integration tests

After establishment of order of integration for all individual series under consideration, VAR model is used to estimate the co-integrating vectors among the variables. First, the

present study estimates model (1) to investigate the long run relationship among human development, sustainable economic development, environmental degradation and other socio-economic factors. For the determination of lag length two VAR versions are initially run: 1 1 and 1 2 lag version. Then Akaike information criterion (AIC) and Schwarz Bayesian criterion (SBC) are used to specify the lags. Results suggest that VAR at lag 1 1 is more appropriate. To establish whether there is a long run relationship among the variables Johansen maximum likelihood approach is conducted. The results from the test are summarized in Table 2, where both the maximal-eigenvalue and trace statistics are used to examine the null hypothesis of no co-integration against the alternative of co-integration. Both trace and max statistics clearly rejects the null hypothesis of no co-integration at 5% level of significance in favor of the general alternatives of seven co-integrating relationships for each test. Therefore, based on the two tests, our annual data from 1970 to 2010 appears to support the proposition that in Pakistan there exist a long run relationship among *human resource development (HD), economic development (EG), environmental degradation (ED), poverty (PV)*, urbanization *(URB)*, *population density (PD)* and *globalization (GL).*

Variables	Level		First Difference	
	Constant	Const. &Trend	Constant	Const.
LEG	-1.84	-1.27	-3.17**	-3.20**
LHD	-0.65	-1.79	-4.85*	-4.82*
LED	-2.45	-2.59	-8.55*	-9.17*
LGL	-0.97	-2.52	-6.05*	-6.97*
LPV	-2.47	-2.80	-3.43**	-4.84*
LURB	- 1.28	- 1.35	-3.75*	- 3.83*
LPD	-2.57	-1.70	-2.78***	-3.28*

Note: Critical values are: -3.6155, -2.9411 and 2.6090 (significant at 1%, 5% and 10% respectively when 1st difference is constant). *, ** and *** represent significant at 1%, 5% and 10% respectively.

Table 1. ADF Unit Root Test

Hypothesized No. of CE(s)	Trace Statistic	Max-Eigen Statistic
None	290.5859*	78.9075*
At most 1	211.6783*	60.0052*
At most 2	151.6731*	50.1254*
At most 3	101.5477*	46.9160*
At most 4	54.6316*	27.3980*
At most 5	27.2336*	16.7314*
At most 6	10.5021*	10.5021*

Trace and Max-eigenvalue tests indicate 7 co-integrating equation(s) each at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.

Table 2. Johansen Maximum Likelihood Co-Integration Test

Next, study move towards the results of co-integrating coefficients normalized on *human development*. The co-integrating coefficient of *economic growth* normalized on *human*

development [see Table 3 panel (a)] show that 1% increase in *economic growth* leads to 0.24% increase in development level of human resource. The elasticities of environmental degradation and poverty are found to be negative and significant. These results suggest that if the level of water pollution increases 1%, condition of human development deteriorates by 0.08%. If the level of poverty increases by 1%, the quality of human development worsen by 0.18%. This indicates that in Pakistan environmental degradation and poverty growth adversely affect quality of human development. The globalization coefficient illustrates that globalization has positive and significant impact on degree of human development. If globalization increases 1% the quality of human resource development will improve by almost 0.09% in Pakistan. The result further demonstrates that increase in population density and rapid urbanization growth do not affect quality of human resource development significantly but the negative sign of population density implies that growing population density may cause to deteriorates the quality of human resource development.

(a) Normalized on Human Development						
LHD	**LEG**	**LED**	**LPV**	**LPD**	**LURB**	**LGL**
1.00	0.2489*	- 0.0786**	- 0.1842**	- 0.0948	0.2243***	0.0936*
Std. error	0.0725	0.0355	0.0938	0.0864	0.1308	0.0298
t-statistics	3.4331	- 2.2141	-1.9637	- 1.0972	1.7148	3.1409
(b) Normalized on Economic Development						
LEG	**LHD**	**LED**	**LPV**	**LPD**	**LURB**	**LGL**
1.00	2.3861*	0.7364	- 2.1008	- 0.2263	- 0.5353	0.2397*
Std. error	0.2882	0.5268	1.3537	0.2049	0.8111	0.0601
t-statistics	8.2793	1.3978	- 1.5519	-1.1044	- 0.6075	3.9883
(c) Normalized on Environmental Degradation						
LED	**LEG**	**LHD**	**LPV**	**LPD**	**LURB**	**LGL**
1.00	1.3579*	- 1.0523*	2.8527	0.3072***	0.7269	- 0.3255*
Std. error	0.1907	0.4059	1.8391	0.1673	1.1482	0.0847
t-statistics	7.1393	- 2.5925	1.5511	1.8362	0.6331	- 3.6792

*, ** and *** denotes rejection of the hypothesis at the 1%, 5% and 10% level of significance.

Table 3. Normalized co-integrating Equations

As far as co-integrating coefficients normalized on economic development concern, the results displayed in table 3, panel (b). The human development coefficient normalized on economic development indicates that 1% increase in the quality of human resource development will boost economic development by 2.38% in Pakistan. The normalized coefficient for environmental degradation is positive but insignificant, suggesting that environmental degradation does not effect the economic development. However, increase in water pollution may harmful, but in the consequence of increase in economic output, water pollution may indirectly cause to speed up economic development. The coefficient of poverty and population density are negative and insignificant, implies to suggest that increase in poverty and population density may slower the process of economic development in Pakistan. The globalization co-integrating coefficient points out that if economy would be globalized 1 percent more then economic development will grow about 0.24 percent more rapidly.

Moreover, the study move towards the results of co-integrating coefficients normalized on environmental degradation [see Table 3, panel (c)]. The cointegrating coefficient of economic growth normalized on environmental degradation explains that one percent increase in economic growth leads to 1.35 percent increase in environmental degradation in the long run in Pakistan.

The long run co-integrating coefficient of globalization demonstrates that 1 percent increase in globalization leads to decrease in water pollution by 0.32 percent. The result suggests that if the economy would be more globalized the economy will move towards more cleaner and more environmental friendly technologies. The long run co-integrating coefficients of human development reveals that 1 percent increase in the quality of human resource development tends to decrease 1.05 percent in water pollution. This result suggests that development of human resource generates the awareness to prevent environmental damages. The co-integrating coefficient of population density normalized on environmental degradation illustrates that if population density increases 1 percent the environmental degradation will worsen by 0.31 percent in Pakistan in the long run. The long run co-integrating coefficients of urbanization and poverty are found to be statistically insignificant and positive, reveal that rapid growing urbanization and poverty may cause to further environmental deterioration in the long run in case of Pakistan.

7. Concluding remarks

The present study explored the long run relationship between human resource development, economic development and environmental degradation along with other socio-economic and demographic factors, such that poverty, urbanization, globalization and population density in case of Pakistan. The study demonstrated that expansion in economic activities, globalization through trade liberalization and urbanization affect human resource development favorably, while increased poverty and environmental degradation has caused to deteriorate the quality of human resource development. The evidence found, suggests that economic development and the globalization are the major factors contributing in the development of human resource. The urbanization also plays a crucial role in the development of human resource, by providing better health and education facilities to people live in urban areas.

The study further found that human resource development and globalization have favourable impact on economic development suggests that development of human capital and growing globalization through trade liberalization are the keys to obtain sustainable economic development. The environmental degradation has not significantly affected the economic development. However, increase in water pollution may harmful, but in the consequence of increase in economic output, water pollution may indirectly cause to speed up economic development.

The results further suggest that the effect of human development is significant to reduce the environmental degradation; while it can play a positive role to attain sustainable development in Pakistan. The human development generates the awareness in people to protect environment and it further improves the economic development of a country. The population density is also adversely affects the environment because due to congestion the planning is more difficult and more populated areas could be more polluted. If we want to sustain our

development, then we have to control water pollution and protect our environment. If we want to attain sustainable development in Pakistan, we have to globalize our resources, increase the serious efforts of poverty reduction, own green and clean technologies to increase industrial and agriculture output, control the growing population and urbanization rate.

According to Jalal (1993), "*two leaks of sustainable development, i.e., poverty and environmental degradation*", the present study found that two leaks are not significantly affecting sustainable development in Pakistan but their signs represent an alarming situation that poverty and environmental degradation may adversely affect sustainable development *unless poverty alleviation and control of environmental degradation are dealt with simultaneously* in case of Pakistan. As far as human development and globalization is concerned they can play constructive and significant role to attaining sustainable development by protecting environment through adaptation of green technologies. Last but not least, there is need to enhance the quality of human resource development in Pakistan that can help to alleviate poverty, increase the awareness of environmental protection and generate the understanding to globalize resources.

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6

Food Insecurity and Nutritional Status in the Population of High Degree of Poverty in Northeast, Brazil

Juliana Souza Oliveira[1], Pedro Israel Cabral de Lira[2], Marília de Carvalho Lima[3] and Malaquias Batista Filho[4]
[1,2,3]*Federal University of Pernambuco*
[4]*Institute of Integral Medicine Prof. Fernando Figueira*
Brazil

1. Introduction

If, in terms of globalized markets, the worldwide availability of food is surplus, at the level of many developing countries and regions, mainly in relation to the social groups and families of low socioeconomic conditions, the irregular access to a basket of sufficient and adequate products for a good health condition and nutrition becomes problematic and thus represent an insecurity situation. It is estimated that more than 800 million people live in this condition (FAO, 2006). The analysis of this situation gathers national food balance sheets (per capita availability), studies on family budgets, income/food prices ratio and consumer surveys at family level, as indicators of monitor labor market and of basic food basket (FAO, 2002).

However, the contingent of families and their members who are not considered safe regarding to physical and economic regular access for full care on their food consumption needs would be much higher than reported on a world scale, regions, countries or areas under adverse socioeconomic conditions (Melgar-Quiñonez, et al., 2005). In this context, situations on food insecurity can be identified by several conditions, such as hunger, malnutrition, specific needs, overweight, diseases caused by inadequate diet and consumption of products harmful to health, such as pesticides, heavy metals, fungi, bacteria and others contaminants.

Currently, situations of hunger as a consequence of food insecurity process is no longer configured as a predominant problem on natural resources limitation or technical knowledge, but the distortions in the production and distribution of wealth between regions, countries and social classes. Thus, the control on food and nutritional situation moves out of the geographical areas where it has traditionally been described to a political dimension, involving human development principles and rights (Valente, 2003).

In reality, the current concept of food security represents a holistic intersectorial and multidisciplinary principles, involving the whole chain of events that goes from food production, consumption and biological use of energy and nutrients, enabling the

nutritional status of individuals, families and population characterization. This way, as for citizenship rights, food security considers as ideal the access to all people, in all places during the whole time, a basic set of food in suitable quantity and quality to meet the energy, macro and micronutrients recommendation needs, thus ensuring a desirable health and nutritional condition (CONSEA, 2006). It is explicit, also that these more specific goals should be accomplished in the context of other rights, such as health, education, culture, participation, ecological preservation and ideally, the exercise of an ethically professional activity and culturally validated as a condition for its legitimacy. It would be (or will be) a citizenship mandate which includes as the most innovative aspect of human development and sustainability.

2. The epidemiological transition and food and nutrition security

Although, epidemiological transition can be considered as an old process, its definition, concept and object of study are still recent. In the sixties, Frederiksen (1969) made important contributions to understanding the economic and demographic transition and more recently, Popkin (1993) for the definition of the nutritional transition.

In essence, the epidemiological transition constitutes the inverse of a historic stage in the evolution of human nosography replacing the predominance of infectious diseases and nutritional deficiencies by a model characterized by the hegemony of non-transmittable chronic diseases combined with overweight and obesity. Therefore, excess of high caloric food make up the unhealthy food pattern, such us high consumption of salt, sugar, saturated fatty acids and calories derived from alcohol intake associated to a recent historical sedentary condition:.

Brazil represents in a worldwide level, a very illustrative example on epidemiological transition, especially in the nutritional field, by means of the speed process, the characterization of a hybrid model (double load of diseases) and its pan-geographic and pan-social diffusion and above all, marked on atypical or paradoxes occurrence.

In relation to the first aspect, it should be noted that, while in the most developed countries in Europe (the Nordic, as an illustration), the epidemiological transition took more than 80 years (i.e. four generations) "to complete its life cycle". In Brazil the same process practically configured itself in around 40 years, less than two generations. On the other hand, the nutritional change occurred in Brazil in little more than three decades, minimized the large geographical differences (South and Southeast Regions, on the one side and the North and Northeast by another), in addition to reducing morbidity nutritional patterns to little significant values between the richer stratum and the poorest layer of the population (Monteiro, et al., 2002).

Also the improvement of the income with the participation of female labor, and the increase in household budgets by cash transfer of the Federal Government Programs, such as the *Bolsa Família* Program (family stipend) is considered an important strategy to combat hunger and poverty, promoting the income increase and giving greater autonomy to families in meeting their needs (Marques, 2005).

From this perspective, with a goal to analyze the behavior of the nutritional status in the context of great changing process, it was considered interesting to focus into two states

(Pernambuco and Paraiba) in the Northeast, the poorest region of the country, with more than 80% of the families classified below the poverty line or with an income of less than one dollar per capita. Two municipalities distinguished by their socio-environmental conditions, remarkably unfavorable were chosen: Gameleira (Sugar-cane region of Pernambuco State) and São João do Tigre (Semi-arid region of Paraíba State). Two decades ago, São João do Tigre was already classified as the poorest municipality in Brazil, while Gameleira is below the 10th percentile in Human Development Index (HDI) in the State of Pernambuco. In addition to this criterion, both cases were considered in their great dependence on rural economy. Because of that, the urban population suffers greatly the unfavorable effects on their agriculture crises'. In Gameleira, the mass of unemployment during the off-season period of sugar cane plantation (March/August); and in São João do Tigre, a livestock zone and multi-agriculture food, the dry season (usually in August till January) demarking a critical cycle in years of crop failure and livestock farming produced by the great drought of the semi-arid weather. What is the situation on food insecurity for these populations? How do they classify the relation to nutritional status from the anthropometric point of view? In the context of nutritional transition, how is the intercession between the nutritional status and food insecurity?

In our opinion, the answer to these three questions make the study uniquely interesting and have important implications for understanding the nutritional transition process in Brazil.

3. The study context

The Sugar-cane region in Pernambuco presents for more than three centuries a social environmental framework of high poverty. This framework has historical roots on sugar-cane monoculture, aggravated by the inadequate use of natural resources and lack of investments in human development (Pernambuco's Government, 2003).

Even with the Federal Programs of cash transfer, in most households where the income is from these (53% of the population belonging to the *Bolsa Família* Program), much of the population lives in poverty, considering that 54% are considered poor by the Social Exclusion Index, which is calculated by deprivation of essential services (education, clean water, sanitation and garbage collection) (Lemos, 2007; Pernambuco's Government, 2011).

The framework of morbidity and mortality in the Sugar-cane region is typical for low-income populations with high incidence of infectious, parasitic diseases, and infant mortality with a growing increase of morbidities of the more developed areas, such as non-transmittable chronic diseases (NTCD's) (Cavalcanti et al., 2002).

The municipality of Gameleira is located in a geographic area of a typical traditional sugar economy: monoculture with high income concentration, unstable labor market between the high employment status (September/March) and the off-season period (April/August), when there is a decrease of manual labor, establishing a critical period of high under or unemployment (Lira, 2006).

For 2007, according to the estimates of the Demographic Census, the municipality had a population of 26.281 inhabitants, which 69.4% reside in the urban area and 30.6% in the rural environment. Even in the urban space, the economic activities are found to be closely dependent on the effects and the demands of the sugar-cane industry (IBGE, 2008a). For

2000, the illiteracy population rate for ages 15 years or more was of 37.8%, households that had water supply connected to a treatment network was 60%. The household sanitary facilities connected to a sewage network were 27.7% and only 46.9% of the garbage was collected (Brasil, 2006a). According to PNUD (2006), the HDI at the municipality was 0.590, represented by sub-indices on education (0.648), longevity (0.627) and income (0.496), with 73.6% of the families living in absolute poverty condition (Pinto, 2007). In 2005, the mortality rate due to diseases of circulatory system was more than twice the number of deaths due to infectious and parasitic diseases.

In another context, geographical reasons (lack of rain, irregularity temporal and spatial rainfall and poor soils) associated with historically unfavorable economic and social factors, having more than half of its inhabitants under the poverty line, as well as the persistence of political and cultural models marked by anachronism, makes the Brazilian semi-arid region a mesoregion potentially more exposed to food insecurity risks and overall and specific nutritional deficiencies (Batista Filho, 2006a).

Effectively, within the overall picture of poverty in the region, the ecological, economic and social problems, and their consequences for the population are exacerbated by a striking asymmetry of the families living in the Occidental Northeast, known as the Drought Polygon. In this context, the scarcity of water is a strong obstacle to the socio-economic development and even for the survival of the population. The cyclical occurrence of droughts and its catastrophic effects are too well known and date back to the beginning of Brazilian history (Beltrão et al., 2005).

São João do Tigre is located in a micro-region of Old Cariris, in the State of Paraíba, composing a conglomerate of municipalities that in the last ten years represented one of the poorest areas in the Northeast, and for this reason, it was chosen for this study (Batista Filho, 2006b).

In 2007, the municipality had an estimated population of 4,578 inhabitants, distributed in the proportion of 28% in the urban area and 72% in rural environment. In 1991, the Human Development Index (HDI) was 0.488, in 2000 rising up to 0.527, represented by the sub-indices on education (0.590), longevity (0.517) and income (0.475) (PNUD, 2006; IBGE, 2008b). According to the 2010 census, 35.8% of the population aged 15 and older was illiterate. In the same year, only 13.1% of households found themselves connected to public water supply and 36.7% of the houses lacked sanitary facilities (IBGE, 2010). Regarding to death causes, in 2005, the main component was a group of diseases of the circulatory system, surpassing more than nine times to infectious and parasitic diseases (Brasil, 2006b).

In 2004, while the per capita income in the State of Paraíba was R$ 4.165,00, São João do Tigre had reached only R$ 2.648,00 (a dollar is equivalent to more or less R$ 1.80 reais) (Lemos, 2007). With this income level, the municipality is classified as the eighth poorest in the entire state, occupying the 216th position in the ranking of 223 municipalities in the State of Paraíba. Life expectancy was 51 years old, one of the lowest in the country, showing a difference of less 20 years in relation to a national average of 71 years of age. Infant mortality rate (71 to 1000 live births) was almost two and a half times higher than found in Brazil (29/1000) (Batista Filho, 2006b). Although there has been an economic improvement in the country as a whole, this region remains as one of the poorest in the country.

4. Methodological procedures

This study was conducted in two municipalities based on three projects funded by the National Council for Scientific and Technological Development (CNPq). The field research was carried out simultaneously for the three projects during the period of March to June 2005 in the municipalities of Gameleira in Pernambuco and São João do Tigre in Paraíba. This is a cross-sectional study, with families including under-five children. The study consisted of socio-economic data, health, nutrition and feeding of children and their families through home visits, clinical and biochemical examinations were performed in local health units.

4.1 Sample and field work

For the sample calculation, was taken into account a prevalence of approximately 60% of food insecurity to the Northeast, on the basis of the PNAD results, 2004 (IBGE, 2006), estimating a maximum error of 5% for a significance level of 95% with an increase of 10% to compensate possible losses, resulted in a minimum sample of 440 families for each municipality. The Statcalc program of Epi info, version, 6.04 was used for this calculation.

The final sample was composed of 501 families in Gameleira (PE) and 458 families in São João do Tigre (PB).

The survey was carried out by interviewing the household head of the family, using a questionnaire, which contained records of the family members, the socio-economic conditions, characteristics of the housing and children's health conditions and food insecurity situation.

Initially, a pilot study was done with 30 families, aiming, in addition to test the data collection instrument and to train the field workers for anthropometric and laboratorial assessment. Free and informed consent of the family members was obtained, including the authorization of the parent or a guardian responsible for the children.

With the objective to verify the consistency of the information, at the end of each working day, the interviewers reviewed and codified the questionnaires in the sector itself, in order to detect possible failures of filling out which required the immediate return to the homes to recover correct information.

4.2 Nutrition variables and food security

The anthropometric assessment was performed according to the technical procedures recommended by the World Health Organization (1995). The body weight was obtained by using digital scales with a capacity for 150kg with a precision of 100g. The children that could not walk yet were weighed in the arms of the companion, whose individual weight was deducted by the total weight of the companion/child.

The children under two years of age were measured in the supine position using an infantmeter with amplitude of 100cm and subdivisions of 0.1cm. Children older than two years were measured standing up and barefoot using a stadiometer with amplitude of 200cm and subdivisions of 0.1 cm. For the adults a Stanley tape with amplitude of 200cm and subdivisions of 1cm was used. All the people studied were weighed and measured without wearing shoes and minimum of clothing.

Variables	Gameleira		São João do Tigre	
	n	(%)	n	(%)
Per capita family income				
≥ 0,25	256	35.3	235	42.8
< 0,25	469	64.7	314	57.2
Matenal Schooling (years)				
≥ 4	312	43.0	326	59.6
0-3	413	57.0	221	40.4
Geografic area				
Urban	351	48.4	305	53.4
Rural	374	51.6	266	46.6
Type of floor				
Tiles/Cement	539	74.3	494	86.5
Mud	186	25.7	77	13.5
Drinking water				
Mineral/Boiled/Filtered/Chlorinated	415	57.2	497	87.0
Without treatment	310	42.8	74	13.0
Sewage disposal				
Public network	355	49.0	312	54.6
Latrine	370	51.0	259	45.4
Colour TV				
Yes	340	46.9	290	50.8
No	385	53.1	281	49.2
Mobile phone				
Yes	116	16.0	12	2.1
No	609	84.0	559	97.9
Motorbike				
Yes	20	2.8	171	29.9
No	705	97.2	400	70.1

Table 1. Socio-economic and household characteristics of under-five children's families. Gameleira – PE and São João do Tigre – PB, 2005

To ensure the accuracy of the measurements, there were two measures of weight and height taken from each person in a condition that the difference between the assessments should not exceed 0.5cm for height and 100g in weight. If these limits eventually were not accurate, a repeated measurement was done and taken the closest values and their average was used for the registration. The interviewers worked in pairs to check the anthropometric measures.

For the nutritional status assessment of children, the Anthro 2007 software was used (WHO, 2007) and children were classified by height-for-age (H/A); weight-for-age (W/A) and body mass index-for-age (BMI/A), expressed in Z-score. The reference standard for classification on weight measures and height was that of the World Health Organization (WHO, 2006), adopting the following cut-off points: Malnutrition: < -2 Z-scores; Nutritional Risk: -2 Z-scores to < -1 Z-scores; Adequate: -1 Z-score to < 2 Z-scores; Overweight: ≥ 2 Z scores.

The instrument used to collect data on food security was the Brazilian Scale of Food Insecurity (EBIA), adapted from a model used in the United States Department of

Agriculture/USDA (Wehler et al., 1992). This tool was previously validated in samples for Brazilian urban and rural populations (Segall-Corrêa, et al., 2007). This is a one-dimensional scale of food insecurity perception that captures the progressive worsening of food access and shows intermediate levels in which families make use of strategies of distributing smaller quantities of food to their members, worsening the nutritional quality and the diet diversification aiming to reduce costs. By these strategies, even with the suppression of some meals, children are saved in less severe situations (Bickel, et al., 2000).

The instrument used to diagnose food (in)security is a 15 questions centrally focused on the experience of the last three months of possible food shortage at various levels of intensity, ranging from concern about lack of food to spending the whole day without eating. Each affirmative response to the questionnaire corresponds to one point and the sum of the points represents the scale score (0-15 points). Scores are classified in levels: 0 (zero) – food security; 1-5 mild food insecurity in families with children under 18 years old; 6-10 moderate food insecurity in families with children under 18 years old; 11-15 severe insecurity in families with children under 18 years old. The sum of positive numbers responses to questions yields a score or gradient of food security or insecurity (Sampaio et al., 2006).

4.3 Analysis of the data and ethical aspects

The data was typed in double entry with the purpose of checking its validation using the Epi Info statistical program. To analyze the internal consistency of the variables, Cronbach's Alpha was used with a minimum acceptable value of 0.85 through the Statistical Package for Social Science (SPSS), version 12.0.1. To verify the association between categorical variables chi-square test was used.

The projects were approved by the Ethics Committee of the Instituto de Medicina Integral Prof. Fernando Figueira (IMIP), attending the standards norms on research involving human beings - Resolution 196/96 of the National Council of Health. Clarification was also provided on the confidentiality of the data. The term of free and informed consent was signed after the interviewee consented in answering the questions and authorizing blood collection.

5. Results

In both municipalities, the food insecurity situations presented exceptionally high frequencies. In other words, food security was found in 11.8% and 12.7% of the families in Gameleira and São João do Tigre, with small variations between urban and rural areas. There was a high occurrence of moderate and severe forms of food insecurity, especially in Gameleira, where 64.4% and 76.5 % of the families were categorized to moderate and severe forms of food insecurity in rural and urban areas. In São do Tigre these food insecurity degrees were of 70.7% and 55.2% in rural and urban areas (Figure 1).

The results presented in figures 2 and 3, show that in São João do Tigre (14.7%), but especially in Gameleira, children's height was the most impaired anthropometric indicator (16.5%). Overweight was at least three times higher compared to the deficit of weight taking into account the body mass index-for-age.

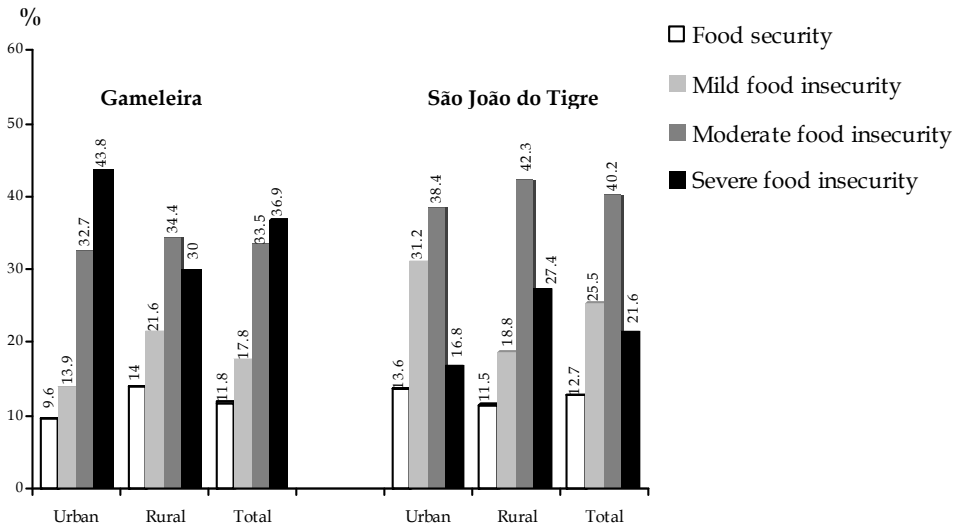

Fig. 1. Prevalence of food (in)security in the families of two municipalities in the Northeast of Brazil, 2005.

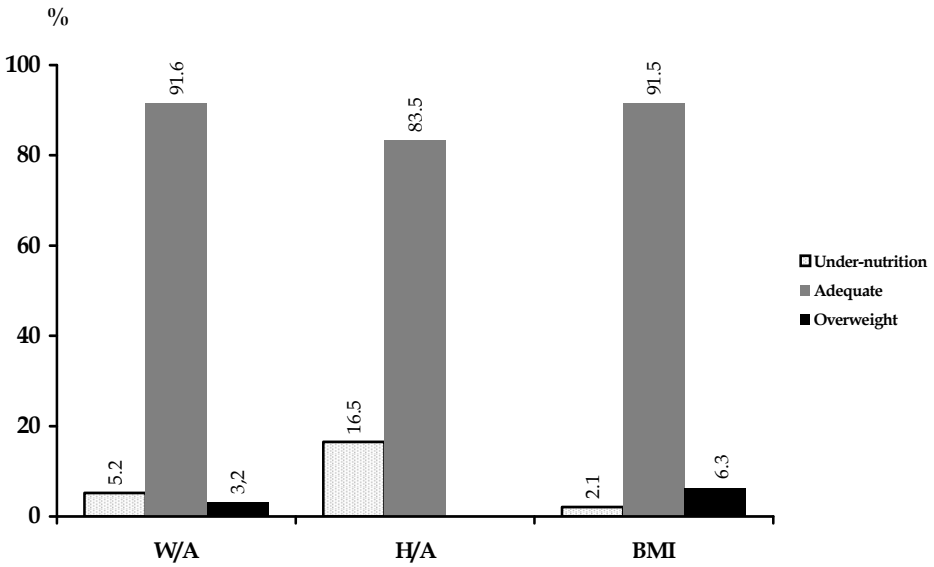

Fig. 2. Nutritional status of under-five children in urban and rural areas according to weight-for-age, height-for-age and body mass index-for-age. Gameleira (PE), 2005

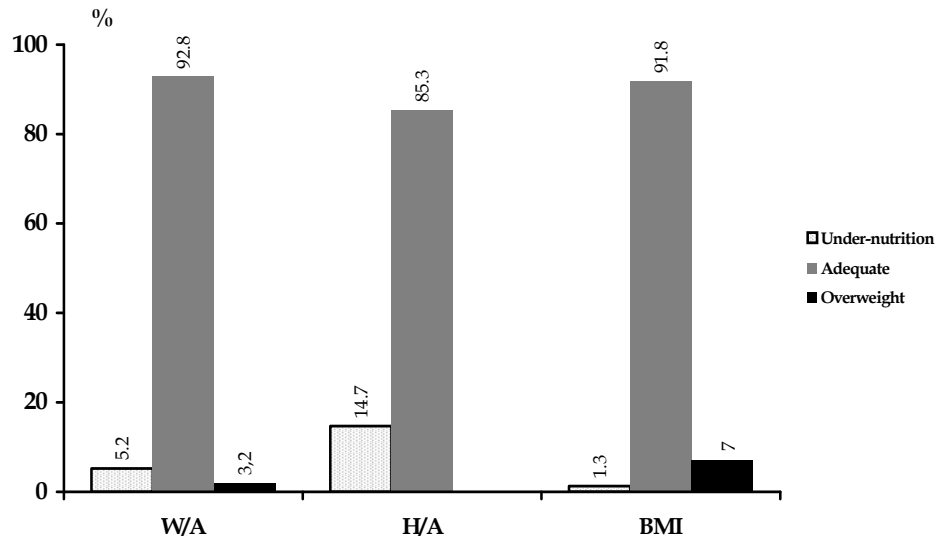

Fig. 3. Nutritional status of under-five children in urban and rural areas according to weight-for-age, height-for-age and body mass index-for-age. São João do Tigre (PB), 2005

In Table 2, the relationship between food (in)security and nutritional status (height-for-age deficit), shows that there is no statistically significant association according to the studied locations.

Food (in)security	Height-for-age				
	Under-nutrition		Adequate		Total
	N	%	n	%	N
Gameleira (PE)[a]					
Food security	8	12.1	58	87.9	66
Mild food insecurity	19	17.8	88	82.2	107
Moderate food insecurity	33	14.2	200	85.8	233
Severe food insecurity	55	18.9	236	81.1	291
Total	**115**	**16.5**	**582**	**83.5**	**697**
São João do Tigre (PB)[b]					
Food security	7	10.6	59	89.6	66
Mild food insecurity	16	12.0	117	88,0	133
Moderate food insecurity	40	17.7	186	82.3	226
Severe food insecurity	19	14.3	114	85.7	133
Total	**82**	**14.7**	**476**	**85.3**	**558**

Chi–square: [a] p= 0.36 e [b] p= 0.35

Table 2. Relationship between categories of food (in)security and nutritional status of under-five children. Gameleira (PE) and São João do Tigre (PB), 2005

6. Final considerations

In addition to the internal consistency of the results expressed by the Cronbach's Alpha coefficient in the two studied locations, four other aspects show the importance, the relevance and interest of the results of this study.

The first one confirming the adverse socioeconomic characteristics of the two populations, related to poverty indicators: very low family income and maternal educational level, and unfavorable housing and sanitation condition. These epidemiological indicators characterizes the diversity of unequal situations that unfortunately still prevails in Brazil.

Moreover, it is observed that approximately 90% of the studied families were classified under the condition of food insecurity, having the majority framed cumulatively within the moderate and severe categories of insecurity. These most adverse conditions, were prevalent in Gameleira, where exceptionally concentrates the best agricultural soils, the largest production of wealth per hectare, per capita income and the longest regular periods of rainfalls in the Northeast. But, on the contrary to the physical geography, economic and technological resources of agro-industrial production such as aggregated values, Gameleira represents the worse adverse situation in terms of food security aspects and nutritional status of their children.

Therefore, it is clear that monoculture of sugar-cane although an exceptionally advantageous activity from the economic point of view, producing good prices on domestic and foreign markets, continues maintaining its character of social stigma recognized historically, since the Colonial times in Brazil with the sugar mills until the Empire and the two Republics (XIX and XX centuries), remaining currently with sugar mills plus alcohol fuel distilleries.

In contrast, in the semi-arid there are poor soils, irregular and scarce rainfall, low level of technology with the hoe moved by man as the agricultural implements mostly used for cultivating lands, and a system of family labor basically developed for self consumption, the food security situation is much less unfavorable. This is the conclusion to be drawn in the results especially when it is considered to be compared to moderate and severe forms of food insecurity. Without a doubt, it is an interesting reflection pointing to a remarkable theme to analyze both situations. In fact, the conditions are well distinct: the Sugar-cane region which is a landowner plantation, monoculture and traditionally focused on the foreign market, in contrast to the semi-arid with dry climate, soils of shallow depth and great fragmentation of small land units. Beside these observations, it should be taken in consideration that at the national level, a large majority of children (66.6% in the urban areas and 56.4% in rural areas) have lived in households with food security (IBGE, 2010). Therefore, the study presented here is a scenario substantially different from that one found in Brazil as a whole, where food security is about 12% only.

In the two studied populations the children height deficit constitutes the most relevant nutritional problem. However, it stands out that the values found in Gameleira and São João do Tigre are higher than those reported at a national level and even in the Northeast region (Brasil, 2009). Even so, it represents a considerable advance in the reduction of malnutrition compared with the situation before 2000. Body mass index-for-age deficit which characterizes current forms of weight deficit in these populations marked by the degree of

poverty the results are fully compatible with data reported for Brazil, which are under 2%. In other words, even in dramatically poor populations, acute malnutrition represents a situation which is virtually controlled in the country since 1989 (Monteiro, et al., 1992; Batista Filho, et al., 2007).

Another non expected result is the high prevalence of normal anthropometric measurements of children according to weight-for-age and body mass index-for-age. The results are equivalent to the international standard of reference (WHO, 1995). This could be, at first, an epidemiological nonsense: the coexistence of high prevalence of food insecurity with a surprisingly favorable anthropometric normality in children. This apparent paradox has already been pointed out in recent results characterizing a peculiar moment of fast nutritional transition process in Brazil (Brazil, 2009).

With this regard food insecurity as a subjective event seems to have its own logic: job insecurity, income, family instability, doubts on social protection network and community solidarity. It would be explained more in the field of social psychology and cultural anthropology and less by the physical anthropology approach or in relation to the somatometry reference indicators, used here for children's nutritional status assessment.

Different indicators of food and nutritional situation should be considered, so that their interpretation would be more emphasized to the complementarily character of both indicators, as to their discrepancy in disagreement between EBIA scale and nutritional status results. In an allegorical language: it is disappearing rapidly the physical consequences of malnutrition, but still remains in people's memory and in the culture of the community the subjective sequelae of food insecurity. This would be a stigma of their own social psychology.

A fourth question may be considered in relation to the characteristic of nutritional transition process. It is evident that even both studied location with markedly unfavorable living condition great changes have been occurring in the Brazilian nutritional reality over the past two decades. It is a systemic process that is practically reaching all the locations in all social classes, even though there are still certain differences. Without a doubt, the sharp decrease on birthrate, the improvement in family income having the participation of female workforce in the job market, the increase in family budgets by official programs of cash transfer (*Bolsa Família* and Food Basket Programs), and access to basic health care, all together have been helping to explain these changes even in the poorest population.

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