Intentionality and free-will: the crucial effects of neuronal networks on human evolution

Giovanni Felice Azzone

Received: 23 November 2011 / Accepted: 23 January 2012 / Published online: 13 March 2012
© The Author(s) 2012. This article is published with open access at Springerlink.com

Abstract Human evolution can be divided into two distinct phases: (1) in the first, human evolution depends on the DNA-gene information based on direct and *predictable* processes, and (2) in the second, human evolution depends on the neuronal networks which generate complex and *non-predictable* effects. In the first phase, the information necessary for the generation of the neuronal cells depends on the DNA-gene information, while the second phase is connected with the formation of complex neuronal networks which is largely independent from DNA-gene information.

Keywords Intentionality · Human · Evolution

1 To what extent does the human mind–brain system contributes to physiological functions and evolution?

In human evolution, the mind contributes to the development of several fundamental properties: (a) the functions involved in communication such as language, vision and many others, (b) the products responsible of the generation of culture, science, morality, technology, art and others, (c) the generation of *intentionality* which is essential for the activation and the regulation of the human behaviours, and (d) the generation of one of the most fundamental mind function, namely that of the *free-will*.

This contribution is the written, peer-reviewed version of a paper presented at the Golgi Symposium on Perspectives in Neuroaesthetics, held at the Accademia Nazionale dei Lincei in Rome on June 13, 2011.

G. F. Azzone (✉)
Department of Biomedical Experimental Sciences,
University of Padua, Via G. Colombo, 3, 35121 Padua, Italy
e-mail: giovannifelice.azzone@tin.it

The evolution of the human brain is characterized by the development of a gigantic number of synaptic connections between neurons endowed with two types of prolongations, namely *axons* and *dendrites*. The operation of a *neuronal network* is dependent upon: (a) the length of the axons and dendrites, and (b) the billions and billions of synaptic inter-neuronal connections (say about 10,000 connections for each prolongation, up to a total number higher than 10^{14} total connections). New properties are generated by the neuronal networks by procedures that are unique in each human mind. One example is that of human *language*, emerged 80,000–100,000 years ago, possibly because of mutations in the Broca's area in the frontal cerebral cortex, and which is essential for the full activity of the human brain. *Intentionality* and *language* are essential tools by which the mind–brain system regulates the behaviours of human beings and their relationships with the outer world. Another fundamental function of the mind–brain system is that of introducing *free-will* in human behaviours. *Free-will* behaviours require: (a) the presence of a large variety of multiple connections between the *gaps* of the neuronal networks, and (b) the use of *intentionality* to perform multiple selections. At variance with non-human species, the evolutionary development of the members of the human species occurs by means of two different *mechanisms*: (a) the first mechanism, lasting between 9 and 18 months, is that which utilizes the information provided by the DNA-gene system, (b) the second mechanism is determined by the development of the human personality. In this second mechanism, two new types of operations are developed: first, the developments of *language* and *intentionality*, and second, the generation of *free-will* and voluntary behaviours. These operations lead to the development of culture, science, technology, art and morality.

2 Do the *mutation–selection* mechanisms provide a satisfactory explanation of the human evolution?

In the biological world, the concept of *evolution* is linked to the name of Darwin; the discovery of the DNA's role in the transmission of information in the new generation has consolidated the Darwinian conception. It has become, then, generally accepted that evolutionary processes, based on the information generated by a mechanism of *mutation–selection* and transmitted by DNA and genes, are capable of explaining all the evolutionary changes that have occurred in the past, and will continue to occur in the future, in both non-human and human species.

Some years ago, a great French scientist Monod (1970), suggested that all evolutionary processes, including those of the human species, operate by means of a mechanism defined as of *chance and necessity*. The question then arises as to whether the mechanism of chance and necessity can provide a complete and satisfactory explanation of human evolution. In major dictionaries, for example, *evolution* has also been defined as follows: a gradual and complete development or act; the slow and gradual transition of inferior and rudimentary organisms to more complex forms. Why there are such wide differences in the description of the evolutionary human processes: from where and how do these differences arise?

3 The limits of an evolution dependent only on the DNA-gene systems

I shall now defend the thesis that whereas the definition of the evolutionary processes, as determined by the mechanisms of *mutation and natural selection*, may be accepted without objection when dealing with the evolutions of non-human species, this is not the case when the problem is that of explaining human evolution. In my view, the definition of evolutionary processes only as products of a Darwinian type of evolution, based on information provided directly by, or generated indirectly through, the DNA-gene system is too limited. The term *Darwinian evolution* is not sufficient to explain the generation of the wide information necessary for the full development of the human species (see Searle 1992, 1997, 2001, 2002, 2004). My conclusion (Azzone 2002, 2003, 2008, 2009, 2010a, b, c) is that human evolution cannot be explained *only* on the basis of the processes depending on the DNA-gene information (cf. Crick 1994; Churchland 1998; Chalmers 2002; Slimansky 2002; Wegner 2003; Richerson and Boyd 2006; Ayala 2009).

My view is that: (a) evolutionary processes operating in the human world are not dependent *only* on the DNA-gene dependent information, and (b) human beings are equipped

also with other very complex, additional, mechanisms which play an important role in human evolution. I shall, then, discuss the evidence in favour of the views that: (a) in the *human world* there is a much more complex evolution, which is also of a different nature with respect to evolution in the *non-human* world, and (b) the neuronal networks, operating within the human brain, generate new types of evolution based on purposeful behaviour and *language*.

4 The distinction between the two phases of human evolution

The most important difference between human and non-human evolutions is that while both human and non-human organisms are subject to DNA-gene dependent processes, the human world is also open to the much more extensive influence of purposeful processes produced by complex neuronal networks. The profound difference is that human biological processes are also dependent on the products of neuronal networks and on *intentional* information. My view, therefore, is that in human evolution the mind–brain system determines processes of adaptation, self-organization and creativity, which are, to a large extent, independent from the contribution of the DNA-gene system.

Which are, then, the two most significant differences between the evolutions of the non-human and the human worlds? First, while in the evolution of non-human species the effects produced by intentions (purposeful behaviour) are almost negligible, in human evolution the effects generated by the complex neuronal networks and caused by *intentions* are of primary importance. Second, the DNA-gene dependent non-human evolution involves events and behaviours which are mostly homogenous and predictable, whereas intentionality-dependent human evolution involves events and behaviours which are mostly non-homogenous and non-predictable.

5 Memes and neuronal networks

Several years ago, Dawkins (1976, 1986) proposed the term *meme* to indicate the concept of “units of the neural-cultural transmission across generations” within the general scheme of Darwin evolution. For Dawkins, examples of *memes* are: the contents of scientific theories, ideologies, literature, arts, religions, human rights, tolerance, and so on. In Dawkins' analysis, the *memes* should be considered as similar to the genes being carriers of immortal essential properties for the continuity of their cultural contents. A somewhat similar proposal had been advanced, almost simultaneously, by Cavalli Sforza and Feldman (1981), who have used the expression “*cultural character*” to

indicate a unit of cultural evolution and reproduction. More recently, an adaptation of Darwin's concept to religion has been described by Ayala (2009).

The neuronal networks, introduced in the present paper, operate as the *memes* of Dawkins and the unit of cultural character of Cavalli-Sforza and Feldman. The replacement of the terms *memes* and *cultural character* with that of *neuronal networks* is based on two considerations. The first is that in the absence of biological references *memes* and *cultural character* appear as a sort of metaphysical entities. On the contrary, the concept of neuronal networks indicates the well-defined role of a large set of components of the human brain–mind. The second consideration is that, during the whole life, the operation of the neuronal networks is accessible to analysis by the neuroimaging technique based on functional magnetic resonance and other modern techniques for brain analysis.

6 The generation of neuronal networks

When and how did human beings acquire, by means of neuronal networks, the capacity to promote a completely new evolution with respect to the evolution solely based on the DNA-gene system? Although the information necessary for the generation of each neuronal cell is always provided by the DNA-gene system, *when*, *why* and *how* has the information generated by neuronal networks become almost completely independent from that generated by the DNA-gene system? I shall now discuss two different aspects of these problems in order to explain: (a) the differences between the two worlds, human and non human, and (2) why, in human beings, the information provided by the mind structures is so deeply different from the information provided by the DNA-gene systems.

First, it should be remembered that neuronal cells with their *axons* and *dendrites* are not static but active entities, in that their synaptic interconnections can change continuously, thus establishing novel combinations within the neuronal networks of the mind–brain structure.

The second problem is that the functions of the mind–brain system are partly dependent on the initial neuronal interconnections determined by the genes, but much more on the very complex neuronal networks generated by everyday life experiences. The activity of the mind–brain system is dependent upon the continuous development of neuronal synaptic interconnections, with each neuron being connected on average with 10,000 other neurons, so that the total number of connections probably exceeds 10^{14} . It should also be remembered that each inter-neuronal synaptic connection can be preserved or discarded depending on whether the connection is useful or useless, i.e.

depending on the use made of each connection during the activities of the whole mind–brain system.

Although the exact number of neurons and synapses present in various species (human and non-human) is not yet known, it is probable that this number differs greatly between the various animal species as well as between individuals of the human species. In conclusion: (a) the number of neuronal networks in the various species is still unknown, and (b) most of the information present in the neuronal networks, so important for the evolution of each human being, has not been transmitted by the DNA-gene system, but has been generated during the human life.

7 The mutations of the Broca's area

Among the most important events within the evolutionary history of the human brain are the mutations of the Broca's area which have generated the human language. The appearance of vocal language, which probably occurred 100,000 years ago, has forced human beings to abandon almost completely the communication by gestures. The generation of language has then become one of the most important differences between humans and other animals. The new information generated in the Broca area, however, is not sufficient for the complete acquisition of language. Much evidence has now been obtained in favour of the view that: (a) the potentiality to develop language is not sufficient to learn the language, and (b) a linguistic environment is required in order to provide a suitable education for learning a language. Language acquisition is dependent on the properties of the social environment (Chomsky 1975; Edelman 1987, 1993). The functions of Broca's area are, then, also an essential, although incomplete, tool for the generation of *intentionality*.

8 The concept of *intentionality* and its effects on evolution

Following previous suggestions by Wittgenstein, many philosophers of mind, in particular Searle (1984, 1992, 1997, 2001, 2002, 2004) have concentrated, in the last 20 years, their attention on the fact that the products of the mind activities tend to direct not only human but also non-human behaviours towards the satisfaction of their *intentions*. The *intentions* of human beings have, on the basis of Searle's conclusions, become fundamental biological properties which tend to direct the human behaviours towards objects or things. A further conclusion is that *intentions* aim to favour the actions and the satisfactions of all living organisms.

As pointed out by Searle, the mechanisms of *intentionality* render the mind–brain system a biological entity which: (a) is additive to, and independent from, that created by the DNA–gene system, (b) renders the mental processes responsible of the properties of free-will as well as of voluntary behaviours, and (c) is responsible for the most important properties and behaviours such as those of culture, science, morality and art. Briefly, the capacity of the neuronal networks of generating *intentional* behaviours—on the basis of an information completely *independent* from that produced by the DNA–gene system—provide the generation of new and additional evolutionary processes to the human world. These new processes—due to the complex capacities of the products of the *neuronal networks* associated with the use of *language*—determine a completely novel and different evolution with respect to that dependent only on the DNA–gene system. This new *intentionality–language* promoted evolution operates at much more rapid rates and at much more global levels as compared with the evolution dependent on the effects of the DNA–gene information.

9 The contribution of *intentionality* and *language* to evolution

Since human behaviours of intentional nature appeared only in the last 80,000–100,000 years, human beings have been capable—before the appearance of language—of expressing their intentions in non-linguistic ways. Probably, human beings not in possession of language, but willing to transmit their intentions to others, used simple gestures and body languages. After a long and gradual evolution, the development of *intentional* behaviours began to occur first in primates and then, about 3 million years later, in human beings. Human beings had, however, to wait three further million years to achieve the capacity of using *language* and then of associating *intentions* with *language*. Although other primates were able to develop beliefs, desires, and other forms of *intentionality* in very primitive forms, only human beings have then been able to achieve the fantastic results provided by the association of language with intentions. The *language–intention* association has therefore played a fundamental and unique role in the complex events which have accompanied the beginning of the development of modern humans 100,000 years ago.

10 The effects of *intentionality* generated by the neuronal networks

The concept of *intentionality* indicates the great variety of mental attitudes directed towards either events or the living

states dependent on mind activities: beliefs, fears, hopes, desires, love, hate, joy, pride, shame, etc. The term *intentionality* comprises, therefore, the ensemble of properties that, during the interactions with the outside world, renders thoughts, feelings and mental attitudes directed towards entities or events occurring either in the outside world or within the mental world. According to the language of philosophers, beliefs, fears, hopes, desires etc. are always expressions of the *intentionality* of human beings (see Searle). In short, the intentionality of the human beings is the special tool by which the mind regulates the relationships between properties which either remain personal or lead to contacts with the outer world.

Searle has also suggested that in human behaviours, a novel fundamental correlation emerges between *intentionality* and *speech acts*. In Searle's view, the intentional states of the human beings, inasmuch as they are manifestations of the states of mind, can be considered equivalent to the interpretations of speech acts (linguistic expressions). The consequence is that the *intentional states*—whose contents, conditions of satisfaction and directions of adaptation are similar to those of *speech acts*—have functionalities also similar to those of *speech acts*. In Searle's view, however, it is the language that derives its functionality from *intentionality*, and not vice versa. This suggestion is in accord with the fact that the information provided by the logical analysis of human language explains the mind intentions (which is the information provided by the content of the language). The nature of *intentionality* may, then, be seen as nothing else but the expression of the conditions which are required to realize the satisfaction of human desires. Intentional states, desires and beliefs have always conditions of satisfaction and directions of adaptation. The *beliefs* of human beings are true or false depending on whether their contents *adapt* or do not *adapt* to the external reality. This means that human *beliefs* have a direction of *adaptation* of the type *mind-to-the world*. On the other hand, the *desires* may be considered as satisfied depending on whether the content of the desires of the mind is fulfilled or frustrated by the world. Therefore, the desires of human beings are satisfied if fulfilled and not satisfied if not fulfilled: in this case, then, the satisfaction is of the type *world-to-the mind*.

11 The nature of *consciousness*

The concept is very popular that the biological operations used by the mind to generate consciousness and its products are not physical in nature. My opinion, in contrast with this conviction, is that if the mind processes, responsible for all consciousness phenomena, would not be physical in nature they would never have effects on behaviour. All

mind operations appear to be capable of interacting with biological structures which are also necessarily physical in nature. My conclusion, therefore, is that consciousness and all its products operate using physical tools. In addition to this conclusion, I also defend two other points of view. The first point of view is that consciousness operates as a normal process of the mind independently of its peculiarity of being able to operate *simultaneously* also in the meta-physical world. The second point of view is that the human mind has the capacity (still unexplained) of operating simultaneously both within a *third person ontology* (which is responsible for the intentionality processes) and within a *first person ontology* (which is responsible for conscious processes). My conclusion, then, is that all mind products, independently from being the result of an ontology of *first* or *third person*, are always the result of chemical–physical operations as are all the other biological entities of the living world.

12 Development and creativity of the neuronal networks

The functions and products of the human mind have been operating, at the beginning of the human life, largely, under conditions of *deterministic chaos*, then moving gradually, depending on the properties of the environment, to the more complex problems such as those of culture, science, art, morality and social life. The nature of these functions and products of the neuronal networks are of great interest for two reasons. The first is that an evolution of a *chaotic* mind–brain system driven by *intentional* mechanisms is naturally much more *flexible and rapid* than one driven by *deterministic* mechanisms (operating on the basis of the principle of *chance and necessity*). The second is that a human evolution based on *intentionality* is much more *creative* due the much larger possibilities of choices.

Popper (1934, 1969, 1972) introduced the new concept of *World 3*, the world of the *human mind products*—in addition to the concepts of *World 1* (the physical world) and of *World 2* (the world of the human mental states, including consciousness). *World 3* includes: the human stories, the material instruments, the scientific problems and theories, the social institutions and the regulations of the human societies, the art products, the principles of morality, and all the other ideas, entities and contributions elaborated by the human mind during the world history.

I have recently proposed (Azzone 2005) to replace the famous Cartesio statement (*Cogito, ergo sum*) with the statement: *I think; then I can create the human world*. In this statement, the human mind is considered responsible of everything existing in the present and in the future human world, inasmuch as it has been the human mind which has

provided the creativity necessary for the generation of the actual world and will generate in the future the innovations of the natural and social world developments.

13 The generation of *free-will*

About 1 year ago, a paper by A. R. Cashmore was published in PNAS (Cashmore 2010) in defence of a thesis which is opposite to the one defended in the present paper. According to A. R. Cashmore: “the laws of nature do not accommodate the concept of free will....it is common to stress that biological systems obey the laws of chemistry and physics; as living systems we are nothing more than a bag of chemicals....The irony here is that in reality, a belief in free-will is nothing less than a continuing belief in vitalism, a concept that we like to think we discarded well over 100 years ago!”. I agree with A. R. Cashmore that if living systems would be *nothing more than a bag of chemicals* then it would be impossible to explain free will. I think, however, that there are good arguments in favour of the view that the behaviours of human beings are much more complex and difficult to explain than are the behaviours generated by a *bag of chemicals*. As discussed in the present paper, several arguments have been provided against the view of the operations of the mind–brain system as produced by a *bag of chemicals*. Other arguments have been provided by the comparisons between human evolution and the evolution of the non-human species. In my view, it is a deep mistake to try to explain human evolution and human behaviour using only the information provided by the DNA-gene systems. As I have discussed previously (Azzone 2010a, b, c), there are fundamental reasons for defending the alternative thesis of the operation of dual and alternative mechanism of human evolution based on the *DNA-gene dependent operations* in the initial phase of development, and on the *intentionality-dependent operations* in a second phase. The point is that the *intentionality-dependent evolutionary mechanisms* of the human species produce effects whose nature and results appear as markedly different from the Cashmore’s descriptions of the *DNA-gene-dependent mechanisms*. Dennett (2003) has argued that if, in the present world, all the phenomena would always be fully obeying to deterministic principles, it would be impossible to have any form of *free-will*. If the human mind would always be operating under conditions of strict determinism, life and behaviour of human beings would proceed towards only one type of possible physical future. The whole life of all human beings would be completely predetermined and would be nothing else but an already written book. The question then arises: can the free-will behaviours of human beings take place in a completely deterministic world? Physicists defend the view

that the indeterminism is certainly true at the subatomic level. But can this subatomic level indeterminism extend to macroscopic systems? Most physicists would not agree with this possibility. In order to address the problem of the non-deterministic behaviours in macroscopic systems such as human behaviour, let us now consider an alternative explanation for the mechanism of *free-will*. A somewhat slightly similar explanation has been recently discussed by Kane (1996) and by Dennett (2003). In my opinion, in order to explain how the human mind could generate the conditions of *free-will*, it may be useful to imagine a somewhat different interpretation of the processes and the interactions between neuronal and synaptic operations. In this new interpretation, the *free-will* types of behaviours of the mind–brain systems should always be favoured by the development of extensive series of synaptic interactions between neurons. The *free-will* decision would be favoured by multiple signals (due to series of multiple, although different, *intentions*) developed simultaneously during the interactions between different neuronal networks, and multiple selections within the *gaps* which have been developed in parallel with the behaviours created by the mind *intentionality*.

14 Human evolution: the two mechanisms

My view (Azzone 2010a, b, c) is that human evolution is the result of a very complex process: in the *first* period, evolution is concentrated in converting the information transmitted by the DNA-gene system into the structures of the molecules and organs that characterize each human beings; in the *second* period, evolution becomes concentrated in translating the potential information generated by the gradual development of the mind–brain system into the large number of tools and concepts which accompany the generation of novel cultural products. The large variety of processes accompanying the growth of human beings suggests that the overall process may be then characterized by two independent evolutionary mechanisms:

(a) The first mechanism utilizes the information provided by DNA-genes for the generation of the various biochemical, physiological, structural components and functions of the human body. This first mechanism for the conversion of the information provided by DNA-genes lasts 9–18 months in the human species, whereas in most other species its duration is considerably shorter.

(b) The second mechanism reflects the utilization of the mind's *intentionality* following the development of the neuronal networks. This exclusively human mechanism can then be further divided into two *sections*. The *first section* generates all the operations required for the use of *language* and *intentionality*, leading to the mastery of both

language and *intentionality* and determining all personal behaviours; this section lasts from 3 to 5 years.

The second section develops the procedures of *free-will* and *voluntary behaviour* which are essential for the acquisition of culture, science, technology, art and morality. This *section* has an unpredictable duration because it depends on the properties of the environment in which each human being is living, and on the variety of the manual activities or of the high specializations of culture, science and art.

In this section, a crucial problem is that of the differences in cultural background existing among the various areas and various social environments of human societies. Because of these deep differences only a great care in education, combined with proper political and cultural choices, can avoid the development of a multiplicity of barriers and social differences existing in the human societies. These barriers and social differences may be much deeper than those of a genetic nature and may lead to dramatic social and political conflicts.

Open Access This article is distributed under the terms of the Creative Commons Attribution License which permits any use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

References

- Ayala FJ (2009) Darwin's gift to science and religion. Joseph Henry Press, NW Washington
- Azzone GF (2002) La moralità come adattamento. Zadig, Milano
- Azzone GF (2003) The dual biological identity of human beings and the naturalization of morality. *Hist Phyl Life Sci* 25:211–241
- Azzone GF (2005) La libertà umana. Bollati Boringhieri, Torino
- Azzone GF (2008) The biological foundations of culture and morality. *Rend Lincei* 19:189–204
- Azzone GF (2009) Beyond Darwin: the second type of evolution based on mind intentionality and selection. *Rend Lincei* 20:345–355
- Azzone GF (2010a) After the genes, the mind evolution. *Rend Lincei* 21:239–252
- Azzone GF (2010b) Perché si nasce simili e si diventa diversi? La duplice nascita: genetica e culturale. B. Mondadori, Milan
- Azzone GF (2010c) The second evolution: after the genes the cultural birth. *Rend Lincei* 21:283–299
- Cashmore AR (2010) The Lucretian swerve: the biological basis of human behaviour and the criminal justice system. *PNAS* 107: 4499–4504
- Cavalli Sforza LL, Feldman M (1981) Cultural transmission and evolution. Princeton University Press, Princeton
- Chalmers D (2002) The philosophy of the mind. Classical and contemporary readings. Oxford University Press, New York
- Chomsky NA (1975) Reflections on language. MIT Press, Cambridge
- Churchland PM (1998) Matter and consciousness. MIT Press, Cambridge
- Crick F (1994) The astonishing hypothesis. Scribner, New York
- Dawkins R (1976) The selfish gene, Italian edition. A. Mondadori, Milan
- Dawkins R (1986) The blind watchmaker. Longmans, London

- Dennett DC (2003) *Freedom evolves*. Oxford University Press, Oxford
- Edelman GM (1987) *Neural Darwinism: the theory of neural group selection*. Basic Books, New York
- Edelman GM (1993) Neural Darwinism: selection and re-entrant signalling in higher functions. *Neuron* 10:15–125
- Kane R (1996) *The significance of free will*. Oxford University Press, Oxford
- Monod J (1970) *Il caso e la necessità*. Mondadori, Milano
- Popper KR (1934) *The logic of scientific discovery*, 1st edn. Einaudi, Turin
- Popper KR (1969) *Conjecture and refutations*. Routledge and Keagan, London
- Popper KR (1972) *Objective knowledge*. Oxford University Press, Oxford
- Richerson PJ, Boyd R (2006) *Non di soli geni*, Ed. Codice, Torino
- Searle JR (1984) *Mind, brain and science*. Harvard University Press, Cambridge
- Searle JR (1992) *The rediscovery of the mind*. MIT, Boston
- Searle JR (1997) *The mystery of consciousness*. The New York review of books, New York
- Searle JR (2001) *Rationality in action*. MIT, Boston
- Searle JR (2002) *Consciousness and language*. Cambridge University Press, Cambridge
- Searle JR (2004) *Mind. A brief introduction*. Oxford University Press, Oxford
- Slimansky S (2002) *Free will and illusion*. Oxford University Press, Oxford
- Wegner DN (2003) *The illusion of conscious will*. MIT Press, Cambridge