# The brain at the centre of the information universe: lessons from popular neuroscience

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Libellarium, VII, 1 (2014): 3 - 15.
UDC: 02:007:[612.8:001.92]
Proceeding of the Summer School in User Studies (SSUS), Zadar, Croatia, 11-14 April, 2012

## Abstract

Insights from the recent wealth of popular books on neuroscience are offered to suggest a strengthening of theory in information science. Information theory has traditionally neglected the human dimension in favour of 'scientific' theory often derived from the Shannon-Weaver model. Neuroscientists argue in excitingly fresh ways from the evidence of case studies, non-intrusive experimentation and the measurements that can be obtained from technologies that include electroencephalography, positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and magnetoencephalography (MEG). The way in which the findings of neuroscience intersect with ideas such as those of Kahneman on fast and slow thinking and Csikszentmihalyi on flow, is tentatively explored as lines of connection with information science. It is argued that the beginnings of a theoretical underpinning for current web-based information searching in relation to established information retrieval methods can be drawn from this.

**KEYWORDS:** popular neuroscience, information science, brain-centred approach.

## Introduction

Information science is a stimulating field in which to work for many reasons. Paradoxically one of these is because it lacks what we are encouraged to regard as the touchstone of disciplinary strength: a powerful and distinctive body of theory. Because the extant theories of information do not always inspire and involve, we are forced to look outwards for ideas and, in addition, research methods and areas of study. The need for eclectic thinking and research might be somewhat frightening, but it offers the imaginative researcher wonderful scope to choose human activity and environments from which to develop perceptions of information in action. In the past this was frowned on. For instance, the doyenne of user studies research, Carol Kuhlthau of Rutgers University, was warned by colleagues that her first steps into what became a successful career-long exploration of people and their relationship with information risked jeopardising her academic future. Fortunately her imagination and determination led her onwards into rich and stimulating areas. Ultimately her research in these areas enabled her to establish user studies as a counterbalance to the rather dry theory of the information retrieval (Kuhlthau 1991). There is much more of this type of path breaking work to be done in information science, both at the micro level (empirical studies of specific problems in well-defined environments) and the macro/theoretical level. To contribute to information science, we still need to look outwards. The contention on which this essay builds is that in the field of neuroscience we can discover something of what we need to create a richer and more meaningful discipline.

What follows is mainly based on a reading of popular neuroscience undertaken by an information scientist. The route into a new disciplinary area is easiest if the discipline has a body of popular writing, and neuroscience very definitely has that. There is a positive outpouring of books, journalism and broadcasts that popularises neuroscience's findings. For instance, high profile broadcasts in the UK include BBC Radio 4's "Brain Season" of programmes transmitted in November 2011, and backed by podcasts and blogs. Soon after, in January 2012, the Royal Institution's 2011 Christmas Lectures (for children) www.rigb.org, "Meet the Brain" by Bruce Hood, were televised on BBC 2. Some, but far from all, of the recent books are specifically referenced in what follows and others (Goldblum 2001; Winston 2003; Zimmer 2005; Edelman 2006; Gay 2009; Hood 2009; Appleyard 2011) were consulted for this paper. At the same time, the articles in the magazines and quality newspapers, many of them in the form of book reviews, are simply too numerous to mention.

In a flow of popularisation such as this there is always a danger that the discipline concerned might be misrepresented in the interests of sensationalism. This reading has been undertaken in the understanding that neuroscience is particularly vulnerable to this. We will not ignore the suggestion which is often heard that popular neuroscience, maybe even neuroscience itself, is exaggerating the capacity of current research to explain the phenomena with which it deals. Despite that, the starting point of this essay is that the literature now offers a knowledge of the brain and its workings which challenges the assumptions of a host of human-centred disciplines. The contention is that disciplines such as theology, psychology, pedagogy, computer science and, of course, information science are all obliged to respond to the findings of neuroscience and generally to concede that their assumptions about human beings have been based on comparatively cloudy perceptions, rooted in insufficiently powerful research.

## Changing information science

A brain-centred approach to information science requires quite a serious re-examination and rethinking of much of what has been written or taught in information science for more than half a century. However, before beginning, we do need to accept that although relevant and helpful knowledge and ideas are abundant in neuroscience, the discipline itself probably still lacks a "big theory" (Ramachandran and Blakeslee 1999, preface). So we need to ask ourselves whether one discipline (information science) can usefully turn to another (neuroscience) which itself is still in the process of developing its body of knowledge and theory. Our contention is that although this involves risk, it is still better than staying safe within the protective envelope of existing theory. This could be seen as a challenge to the paradigm of the discipline. That would be a big enterprise to undertake, and cynicism about suggestions concerning paradigm change is natural. Raymond Tallis, one of the most penetrating critics of the enthusiasm for neuroscience, strikes out hardest against it. He suggests that "*A new paradigm* means lots of lovely conferences and papers" (Tallis 2011, 60). However, he does go on to add that "It may also help you to overcome a crisis of confidence in the value or validity of what you are doing". This is surely the point: an entry into the area of basic theory can be well worthwhile, but it does require "lovely conferences and papers" and it is not always popular.

It is our contention that in most of the considerable body of writings on information theory and the theory of information seeking in particular, no role or insufficient role has been offered for the human brain. Yet the brain is the organ in which information arguably becomes information, and certainly takes on any of the significance which it might have. Information science is at its least helpful when it takes a simplistic view of the mind and makes use of the Shannon-Weaver model which deals with the problem in communication science of transferring signals over a "noisy" channel (Shannon and Weaver 1949). But as Rose (2005, 103) puts it: "Affect and cognition are inextricably engaged in all brain and mind processes, creating meaning out of information – just one more reason why brains aren't computers." A summation of ideas on information seeking, such as that by Wilson (2000), shows how it has been much refined and adapted over the years. Cognitive psychology has moved much more to the centre of the discipline's thinking on human responses to information. Yet there remains at its core a sense that the mind is best understood by likening it to a computer, and that much of what needs to be said can be regarded as a matter of machine talking (as effectively as possible) to machine.

If we turn to the best recent titles on information the tendency persists. Gleick (2011) is a fascinating and stimulating read, full of stories and examples, but essentially it does not stray far from the Shannon-Weaver perspective. Floridi's (2010) elegant and persuasive thoughts on information, can still be read as dealing with information as if it were a phenomenon independent of the observer or receiver. Thus he writes of categories such as mathematical, semantic, and biological information, adding in a chapter on neural information (Floridi 2010, 86) that "The brain is still a continent largely unexplored. One of the great informational puzzles is how physical signals, transduced by the nervous system, give rise to high-level, semantic information". This is surely true, but that puzzle is right at the centre of any worthwhile theory of information and we need to address it however problematic the means available to us might be.

In most theory on information seeking, the "mind" of an imperfectly articulated "self" has sought and received information acquired in positively structured ways that, on reflection, bear little resemblance to the hunches and inspirations of real life engagement with information, or indeed its confusions and compromises. The information scientist's notional information seeker has moved in a conscious way from the first imprecise perception of an information need, through to the need's definition and refinement, its transformation into search terms that can be used to address information resources and the obtaining of an appropriate response when they are so addressed. Whether it is acknowledged or not, this looks like a Shannon-Weaver inspired approach. Unusually, a keynote speaker at the 2012 BOBCATSSS Conference in Amsterdam (Shapiro 2012) did proffer some means to mend Shannon-Weaver, which he described as broken (or, in his oral presentation, inadequate in the first place). In defence of information science, neuroscience has until recently offered only limited help in theory making. Knowledge of the brain has been tantalisingly incomplete and not especially helpful to the layperson. That has changed. If we ask why there has been a change, the answer is solidly based in the technology available to the research scientist.

## Neuroscience

In the past, there was only a limited range of approaches from which to derive an understanding of the brain. A wonderful exhibition at the Wellcome Collection in London in May 2012 (Kwint and Wingate 2012) graphically illustrated these in striking, frequently bizarre, and often inspiring detail. Today, medical ethics generally rules out intrusive investigation and experimentation with the brains of living human subjects. Dissection of the brains of dead subjects had established the basic shape and structure of the tissue in Hellenic times. The various parts of the brain were named and gradually some comparatively clear idea of functions performed there has been developed. A crude version of some of this might say something like – we can observe that the brain has two hemispheres, each split into four further components: occipital lobe (connected visual processing); temporal lobes (language and sound processing); parietal lobes (perceptions of space); frontal lobes (thought and planning). The distinction between the two hemispheres is important and we will return to that in the following section. Beneath the hemispheres there are the structures of the limbic system which are often spoken of as the seat of the emotions, and the hippocampus which plays a part in the storage and retrieval of memories. Then there is the cerebellum, at the back of the brain, that is increasingly seen as the seat of various aspects of cognition, including language and reading. Further reading on any of this reveals that neuroscientists have identified a great deal about the functions these and other parts of the brain seem to perform and how they interact with each other. However, the attempt to tie any specific brain function exclusively to one brain area has been a failed project. What happens in the brain is much more complex than that.

Some insight into that complexity was developed in the nineteenth century, when a great deal was learned by inference from the experience of people who had suffered brain and other neurological injuries. Whilst at first people's response to brain injury was used to infer which functions were dependent on the damaged area, later it became clear that the brain has a degree of plasticity that enables it to compensate for much damage. One of the first widely studied and publicised instances of brain damage as a clue to brain function was that of Phineas Gage. In 1848 whilst working as an engineer on railway projects a premature explosion drove an iron shaft completely through the frontal lobes of his brain. This did not kill him or damage many of his mental functions, but it does seem to have affected his personality, rendering an amenable and efficient personality irritable and erratic. Gage's case encouraged theorising on the function of the frontal lobes and, presumably, also the medical use of lobotomy to treat personality disorders. Subsequently, physicians and neuroscientists have looked in detail at the way in which compensatory changes have occurred after damage to areas of the brain (Ramachandran and Blakeslee 1999; Ramachandran 2004).

The important point is perhaps that the brain has an amazing capacity to switch functions between areas in response to damage, which suggests that communication and what we might call cooperation between areas of the brain is at least as important as specialisation. It also seems that the brain grows and strengthens according to the ways in which it is used. A clear formulation of this is offered by Carr (2010):

> "The recent discoveries about neuroplasticity make the essence of the intellect more visible, its steps and boundaries easier to mark. They tell us that the tools man has used to support or extend his nervous system – all those technologies that through history have influenced how we find, store, and interpret information, how we direct our attention and engage our senses, how we remember and how we forget – have shaped the physical structure and workings of the human mind. Their use has strengthened some neural circuits while leaving others to fade away" (Carr 2010, 48).

What Carr is pointing towards here is the anxiety that use of the Internet is actually changing users' brains, and maybe not for the better. There is the germ of a research programme in this suggestion and information scientists by turning to current neuroscience seem now rather well equipped to pursue it.

What has made greater progress in research in neuroscience possible is the availability of a range of sophisticated scanning techniques. In the first half of the twentieth century, ways of measuring blood flow and electrical charge in the brain began to be developed. From the former, the technique known as Positron Emission Tomography (PET scanning) was developed to provide three dimensional images of the brain at work. Since then, Magnetic Resonance imaging (MRI) and functional MRI (fMRI) have been developed to provide images of even greater clarity. Now Magnetoencephalography (MEG) can read very small traces of magnetic activity during periods of thousandths of a second. Today, the activity of a single neuron can be monitored, as can many neurons working together. "Using PET scans and fMRI, we can now find what parts of the brain are active or inactive when a patient performs a specific action or engages in a specific mental process" (Ramachandran 2004, 85). In this way previous vagueness about what actually happens in the brain is in the process of being reduced.

One of the most important consequences of this is that the more we learn about the brain the less obvious it seems that there is a specific location for consciousness. The challenge of locating consciousness has been described as "how intentional reasons can be reconciled with neural causes through many-to-one mapping of neural activity onto cognition" (Scholl in Gay 2009, 177). It is detailed awareness of the neuroplasticity of the brain that has led to the conclusion that is not necessarily to a specific area of the brain that we must look for understanding of any aspect of brain function, but to the neural connections between parts of the brain. The sum of all these connections is now often referred to as the connectome (Seung 2012) and there is a kind of mantra: "You are your connectome", or as Le Doux (2002, ix) puts it "You are your synapses". This moves us closer towards being able to say something useful (to information science and other disciplines) about human consciousness.

In particular there is a new understanding of the significance of consciousness in relation to the host of automatic functions that the brain performs. This relates to a line of enquiry that has been pursued intensely since Freud pointed out more than one hundred years ago that at least half of what goes on in the brain takes place at a subconscious, or unconscious, level. Probably the Freudian perspective concentrated too exclusively on the problems and disturbances that the unconscious mind causes our conscious selves. This might, in turn, have distracted our attention from the positive role played by the autonomic nervous system which can, for instance, identify things like statistical patterns well before consciousness does. In fact as Eagleman (2011, 131-132) puts it, "Almost all of our actions are run by alien subroutines, also known as zombie systems". Learned and instinctive systems generally work in managed relationships. Consciousness is needed when there is a new problem to solve: it offers the cognitive flexibility that zombie systems cannot offer. Eagleman concludes that consciousness is useful, but only in small amounts for specific tasks (such as long term planning).

In this view of things, the unconscious brain serves consciousness on a need-to-know basis, ignoring things until systematic thought is necessary and then providing the information, in a highly processed form for contemplation and decision making. We ourselves are not aware of the vast majority of our own brain's activities and we couldn't cope if we did know what was happening. The fact that this might seem to reduce humanity to a set of automatic, subconscious responses, some of them described by the ugly word zombie, particularly disturbs those who feel that a less (potentially) reductive interpretation is required. For instance, Hick (2006, 205) points out that "Not only all personal relationships, but all creative work in literature, painting, music, architecture, and equally in all the great scientific advances, pre-supposes a significant degree of intellectual and physical freedom." Well, yes, but what does "significant" mean in this context?

Perhaps the most robust, but also tantalisingly flawed, approach towards answering this question is that of Tallis (2011) who regards the human mind as much more than the sum of the neural activity which we are currently able to measure. Indeed he identifies a phenomenon he calls neuromania, by which he means the belief that what we can learn from neuro-imaging explains virtually all mental phenomena. He draws attention to a "gap, which cannot be closed, between experience and what neuroscience observes" (Tallis 2011, 97). He then adds that in his view "The claims for correlations between psychological functions and brain activity based on neuro-imaging techniques are very dodgy indeed" (Tallis 2011, 193). Some of the problem he traces back to the use of the Shannon-Weaver model, arguing that it dehumanises perception, attention and awareness in human beings in favour of an emphasis on a neutral definition of information, unconnected with meaning or significance. His message is intended as a salutary warning to those who dabble with neuroscience. But Tallis's angry mode of expression and his consistent rejection of biological/evolutionary arguments ('darwinitis', in his terms) often leads the reader to expect that he will find a place for something like an immortal soul in accounting for human achievement. As a self-proclaimed humanist atheist he rejects this, but his unwillingness to be very specific about what exactly he thinks makes human beings so unbound by their measurable brain activity is ultimately unsatisfying.

Tallis's polemic encourages us to be cautious in our dealings with neuroscience, which is good, but he offers no convincing alternative. After reading him we return again to our contemplation of the interaction between subconscious and conscious to which neuroscience draws our attention. Reduced to rather simplistic level, what we obtain from our reading of neuroscience is that we are both creatures of instinct and rational individuals. In the scientific observation of the workings of the brain we can now see both of these aspects of our selves in action. If we then turn this notion to our relationship with information, it begins to appear in a new light. Information is what it is because we are what we are, and we are brains, at the centre of a sensory apparatus that feeds us with perceptions, with an individuality conditioned by our social existence with other human beings. With the brain as a consistent starting point for our theorising we are obliged to engage with the questions that form the disciplinary area of information science in fresh ways. Just exactly what those ways are and where they lead us can only be sketched out as a set of suggestions at present and the next section is only a tentative entry into the field.

## Information implications

The idea of the brain as an organ that receives and processes massive quantities of information in a host of deeply or lightly coded forms, but not necessarily dominated by conscious intervention naturally leads us to ask "Is this where we will find significant implications for information seeking and use?" We would answer this in the affirmative, whilst admitting that the implications are comparatively imprecise. To make some progress towards better answers, we can turn for help to writers who have relevant ideas about human abilities and behaviour. Here we will make some use of the ideas of two distinguished and academically respected writers: Daniel Kahneman (Nobel Prize winner and Emeritus Professor at Princeton University) and Mihaly Csikszentmihalyi (formerly of the University of Chicago and now Claremont Graduate University). They are not alone in putting brain activity somewhere near the centre of what they say: nudge theory does this too (Thaler and Sunstein 2008). This is a libertarian paternalistic attempt to understand social behaviour and identify ways of subtly pushing (nudging) the public in one direction or another. It seeks to bypass "top of the mind" perceptions and to access "unconscious feelings and emotions" by using data gathering methods such as focus groups. In this it shares a great deal of ground with the manipulative marketing techniques used by business corporations to influence consumers' attitudes towards their products and services. This kind of exploitation of the unconscious mind to act in ways that conscious consideration might reject is not exactly what we are discussing here. In contrast, both Kahneman and Csikszentmihalyi offer approaches which offer to optimise human effectiveness through recognising the duality of the brain.

Before looking at what Kahneman has to say, it is important to note that there is a distinction, clarified first from studying patients with damage to one hemisphere of the brain, and subsequently given support by neuro-imaging, between the functions of the left and right hemispheres of the brain. Until the 1990s, there was a sense that the left hemisphere of the brain was much more important than the right, because of the strong evidence that it is the significant location of the rational and language-related activities of the brain. In a sense this almost dismissed the right hemisphere as an area where the necessary but "lower" automatic, animal processes of the brain took place. However, studies of patients with right hemisphere damage showed that there could be a loss of significant areas of understanding, such as the interpretation of pictures and maps, the use of metaphors and jokes, and a grasp of the links between ideas and an ability to make sense of problems holistically. It seems to be the right side of the brain that produces answers to questions and problems "out of nowhere". Lehrer (2012) associates it with human creativity. The left hemisphere produces answers more slowly, working hard to search memory, test ideas and reason out solutions, but often seems to get tired and experience difficulty progressing. The right hemisphere then seems to take the information, experience and ideas generated by the left side and seek answers through associative processes. What is more, the emergence of an answer is often marked by increased evidence of electrical frequency activity in the anterior superior temporal gyrus, which is located in the right hemisphere.

What Kahneman (2011) does is give a slightly different twist to the balance just described. He talks of System One (right hemisphere) which thinks fast, is intuitive, associative, metaphorical, automatic, impressionistic and cannot be "switched off". System Two (left hemisphere), in contrast, thinks slow, is deliberate, attentive and hard working. In problem solving it is brought in to play when things get difficult. This is the conscious being; the self that seems to define us as individuals. Kahneman points out that for the most part System Two effectively defers to System One. The problem, as he sees it, with System One is that it is not good with detail and rushes to conclusions in a way that might prove inadequate because it can be irrational, biased, and prone to interference effects. In consequence "As we navigate our lives, we normally allow ourselves to be guided by impressions and feelings, and the confidence we have in our intuitions, beliefs and preferences is usually justified. But not always" (Kahneman 2011, 4). He argues that System One can be a problem because it is prone to mistakes based on misplaced confidence and System Two, which introduces scepticism, is needed to handle complex and difficult problems. Kahneman's main concern could be said to be the encouragement of critical thinking and well-reasoned solutions through the more effective use of System Two. This implies that what we need in life, and in our interaction with information, is an optimum reliance on fast or slow thinking; right and left hemisphere cooperation; and System One and System Two balance.

Where we might find interesting pointers towards this balance is in the idea of "flow". This concept elaborated by Csikszentmihalyi (1990), describes a mental state of full immersion in a mental or physical activity to the extent that there is a loss of self-consciousness and the emotions are directed towards a full involvement in performing and learning. Elements of this approach can be identified in eastern meditation techniques, in educational systems such as the Montessori Method, and in the advanced coaching of sportspeople. As Csikszentmihalyi describes it, it is the ideal harmonisation of Kahneman's System One and System Two, in the interests of effective, and ultimately satisfying, activity. Consciousness in a state of flow harnesses our intuitive reception of information in a purposeful way.

> "The function of consciousness is to represent information about what is happening outside and inside the organism in such a way that it can be evaluated and acted upon by the body. In this sense, it functions as clearing house for sensations, perceptions, feelings and ideas, establishing priorities among all the diverse information. Without consciousness we would still 'know' what is going on, but we would have to react to it in a reflexive, instinctive way. With consciousness we can deliberately weigh what the senses tell us, and respond accordingly" (Csikszentmihalyi 1990, 24).

In flow the brain uses both systems in a balance that is appropriate to the occasion and need. In sports, for instance, we can talk of *the zone* as a perfect balance between conscious intent and a complex set of subconscious perceptions and calculations. A ball coming at a fielder in cricket or baseball with a velocity and curve of trajectory that the eye does not have the time to formulate as a single coherent message to the receptor areas, and so hard and heavy that the hands must be perfectly placed to receive it and soft enough for it to sink into them and stay, will never be caught by conscious calculation.

If we try to turn this to real life information use situations, flow can be identified very closely with the intuitive nature of searching and surfing the web. The web and its hyperlinked resources are particularly conducive to the experience of flow because the human brain (the right hemisphere in particular) is particularly adapted to exploring resources and searching opportunities that have naturally associated structures. Decisions based on systematic planning are less important than following the implications of connections that are offered incidentally in the course of scanning and reading hyperlinked content. It is true that one can experience more or less this phenomenon in a great library, which on the face of it is essentially adapted to the rational, left hemisphere, approach. At the end of a day in a major research collection one is surrounded by a pile of books fetched from the shelves in response to clues and bibliographical guidance obtained along the way. The outcome may well be a thorough enlightenment on some topic. This is, however a very clumsy process, delightful though it may be, requiring catalogue use, conversations with librarians, trips up and along the shelves, consultation of book indexes and other time-consuming activities. It is flow, but not as we have come to experience it. The brain can handle these connections, clues and pointers much faster than a library can offer up the resources. It is as if we have been waiting for something that can respond to our inherent capacity to work in the flow. Today the wait is over, we do have an answer, or the best answer available at this juncture, in the form of the web. It cannot tell us everything we might need to know and it might well provide us with poor or deceptive information. However, it does enable our consciousness to put into play what is clearly our default information gathering mode, which is intuitive, right hemisphere, and definitely System One.

So, to summarise, there is just too much happening in the brain at any one time for the conscious mind to handle the data and calculations that even a simple process, like standing up and walking for a few paces, requires. Most of what we do (and think) is handled somewhere below the level of consciousness. Once we recognise this in relation to our educational, professional and leisure use of information, we can see that an information activity that provides a guaranteed direct line between the need to know (apprehended or implicit) and some form of resolution of the need is almost inconceivable. One line of enquiry, one document with one answer is just not the way we need to work and assuming that there is may even inhibit the power of our brains to work most productively. We need a broad exposure to information of the kind we could find in a very big, very accessible library, and of which we now have a virtual equivalent available for our use on both fixed and mobile devices through the web. We can immerse ourselves (browse or surf), quite naturally achieve the flow, experience serendipity, let our imagination run free and reach unexpected conclusions. What we are doing is essentially accepting the message, implicit in so much of what we learn from neuroscience. This is that we need to free ourselves from an unhelpful over-concern with the conscious mind and put the whole of the brain at the centre of our information universe.

## Conclusion

This attempt to learn something relevant to information science from popular interpretations of neuroscience has been used to propose a brain-centred approach to information science. Certainly we hope that the usefulness of neuroscience-related approaches on small scale projects is apparent. To take a single example, the implications for information literacy are considerable. We have suggested above that we need to accept the significance of our fast, left hemisphere, System One mental activity in our relationship to information. If we go down that route, then the embedding of a discriminating and skilful approach to information in people's System Two mental activity moves to the centre of our concerns. System One searching is exciting and productive, but implicit in it is the danger of the intrusion of a certain degree of error, bias and confusion. This calls for a counterbalance. Information literacy programmes seek to empower the searcher, and the first step in that empowerment is to understand the strengths and weaknesses of individual mental processes. Once that is established, selection of the most suitable content for programmes and methods of assisting learners can be devised. In this we can possibly identify another potential line of enquiry from which a brain-centred approach might demonstrate its ability to generate a research programme. A research programme would necessarily try to make use of the brain scanning techniques discussed earlier. Concerned not merely to be a bearer of suggestions for others to pursue, at the time of writing the author is discussing ways of doing this with colleagues who have access to a suitable facility.

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## Sažetak

**Mozak u središtu informacijskog svijeta: pouke iz popularne neuroznanosti**

Rad daje uvid u recentno obilje popularne literature o neuroznanosti s ciljem jačanja teorije u informacijskoj znanosti. Teorija informacije tradicionalno je zanemarivala ljudsku dimenziju u korist 'znanstvene' teorije, često izvođene iz Shannon-Weavera modela. Neuroznanstvenici joj mogu dati osvježavajuće argumente na temelju dokaza izvedenih iz studija slučaja, eksperimenata i mjerenja dobivenih uporabom tehnologije koja uključuje elektroencefalografiju, pozitronsku emisijsku tomografiju (PET), funkcionalnu magnetnu rezonanciju (fMRI) i magnetoencefalografiju (MEG). Podudarnosti zaključaka neuroznanosti s idejama poput Kahnemanove o brzom i sporom mišljenju ili Csikszentmihalyijeve o toku promišljaju se kao poveznice prema informacijskoj znanosti, koje mogu dati teorijsku podlogu za promišljanje traženja informacija u mrežnom okruženju u odnosu na uspostavljene metode informacijskog pretraživanja.

**KLJUČNE RIJEČI:** popularna neuroznanost, informacijska znanost, pristup usmjeren na mozak (*brain-centred approach*).