How neuronal oscillations code for temporal statistics

VALORIZATION ADDENDUM

> Valorization: "*the process of creating value from knowledge, by making knowledge suitable and/or available for social (and/or economic) use and by making knowledge suitable for translation into competitive products, services, processes and new commercial activities*" (Maastricht promotie regelement, 2013).

Valorization of this thesis

In this part of the thesis I am supposed to write about the value of the knowledge that I created with my research. Since 2014 this is an obligatory part of all theses that are produced at Maastricht University. At a first sight it sounds fair to make your research valuable by "*making knowledge suitable and/or available for social use*" as tax payers are investing in us. However, what does this exactly mean?

I would interpret the definition "*making knowledge suitable and/or available for social use"* as implying that everybody in society can access the knowledge I created ("availability"). This thesis will be publicly available at the website of Maastricht University from the day of my defense on. Moreover, anybody can get a copy if they approach me. So the availability of my research is confirmed. Valorization seems to be an easy task. But I am forgetting one word here, the word "*suitable*". This would mean that the knowledge I am creating should be at a level at which society can understand it. This is going to be trickier as this depends on people's background knowledge. I operationalize "*suitable*" when people outside my research field can understand it. I guess this would require that I would rewrite my empirical chapters in short understandable language (I also refer to lolmythesis.com for others trying this). Fair enough:

Chapter 2: Detecting soft sounds is easier when you know when a sound is arriving.

Chapter 3: Brain waves track sounds when they are presented rhythmically.

Chapter 4: Brain waves only track sounds when you know that a sound will occur in the first place.

Chapter 5: Brain waves are slower when you are unsure about the exact point in time when the sound will occur.

Chapter 6: People use timing information created by mouth movements in syllables to identify them.

Chapter 7: Different syllables are represented at different time points on a brain wave.

Chapter 8: Some regions in the brain respond to sounds. The same regions respond different when an identical sound is presented to different time points on a brain wave.

Although this is a very brief summary, it is in more or less simple terms what all the chapters were about ("suitably available" knowledge). Anybody can use this for any social and/or economic purpose. If more detailed information is required I would be happy to communicate this further. It seems that I am done with this chapter. Let's double-check with the guidelines in the regulations whether I fulfilled the requirements:

"Five questions are provided that can guide candidates in writing this addendum

1) *(Relevance) What is the social (and/or economic) relevance of your research results (i.e. in addition to the scientific relevance)?*
2) *(Target groups) To whom, in addition to the academic community, are your research results of interest and why?*
3) *(Activities)/Products) Into which concrete products, services, processes, activities or commercial activities will your results be translated and shaped?*
4) *(Innovation) To what degree can your results be called innovative in respect to the existing range of products, services, processes, activities and commercial activities?*
5) *(Schedule & Implementation) How will this/these plan(s) for valorization be shaped? What is the schedule, are there risks involved, what market opportunities are there and what are the costs involved?"*

This seems relatively far from the core definition of valorization as defined in the regulations, in my opinion. While in the original definition

I am required to make my knowledge *available* at a suitable level for society, these guidelines require me to also decide on *how* this knowledge is utilized by deciding the relevance, possible products, and even when this is all going to be made. I thought that as a scientist I was required to create knowledge. Just like an artist is creating art, a scientist creates knowledge (science literally means knowledge). Other professions and society should profit from this knowledge, I fully agree with this. But according to the operationalization of valorization above I should not only create the knowledge, but also implement it in society. Moreover, it seems that I should even let my research be guided by this, because how could I answer these questions if my research is not directly relevant for society in the first place? This would mean a goodbye for the pure scientist, the creator of knowledge and a hello to the periodontist, the creator of relevance.

Valorisatie van onderzoek als taak van de universiteiten?

More than ten years the government has been promoting valorization in the university. It first affected the universities in 2005 when the letter "*valorisatie van onderzoek als taak van de universiteiten*" appeared. In this letter it is explained that valorization is one of the core tasks of university, next to creating education and doing scientific research. It is a basic statement that universities should think about what type of research they are doing and how this information can be conveyed to the society (which in principle I do not oppose to). But let me just elaborate on the specification of this letter since this letter is one of the starting forces why I am writing this section in my thesis in the first place. The letter starts out as follows (freely translated): there is no discussion that a significant part of academic research should not be aimed for any direct or indirect societal use, but to maintain and contribute to worldwide scientific developments. The agenda is not decided by any societal question, but by the research possibilities. ("*Buiten discussie staat dat een belangrijk deel van het universitaire onderzoek niet primair gericht moet zijn op direct of indirect maatschappelijk nut, maar op het bijhouden van en bijdragen aan wereldwijde wetenschappelijke ontwikkelingen. De agenda wordt echter niet bepaald door de maatschappelijke vraag, maar door de onderzoeksmogelijkheden*"). This type of research was defined as "offer based": research done to create scientific developments

("*aanbodgedreven: het wordt gedaan omdat er snelle wetenschappelijke ontwikkelingen zijn of te verwachten zijn*"). Next to this offer based research, universities were required to provide "question based" research: research aimed for answering societal questions ("*het geven van antwoord op maatschappelijke vragen. Het kan zowel gaan om vragen van bedrijven als van de overheid en van niet-commerciële maatschappelijke organisaties*"). Let us ignore the poorly chosen definition as all (proper) research is based on a research question and agree that it is valid to have research performed for scientific developments as well as societal relevant questions and that a balance has to be found. Here comes the problem of this letter that universities face: universities are required to prioritize within the offer based research, research that has the possibility of creating a synergy between business and societal parties, and the subsequent possibilities for economical and societal valorization, and responsibly report the results of this "prioritization". ("*Wij verzoeken de universiteiten en onderzoekinstellingen dan ook om in hun strategische plannen aandacht te besteden aan de mogelijkheden om bij de prioriteitsstelling binnen het aanbodgedreven onderzoek de mogelijkheden tot het scheppen van synergie met het bedrijfsleven en maatschappelijke partijen, en de daaruit voortvloeiende mogelijkheden tot economische en maatschappelijke valorisatie, expliciet mee te wegen en om in hun verantwoording te rapporteren wat daarvan het resultaat is geweest.*"). I freely interpreted this as the proposal that although offer based research should not be guided by societal questions, universities should fund offer based research that anyway answers these societal questions.

How did the minister think about the practicalities of this? We, scientists come up with research questions in our "offer based", non-societal relevant manner and offer this research to the world. The universities just fund whatever by chance also seems to answer a societal question. And the scientific research questions are magically uninfluenced by this "prioritization" scheme of the university. Let us be honest here, if universities truly implement this suggestion funding only applies to scientists with research questions that have societal relevance. Thus, no more offer based research, but only societal relevant research.

Is it a problem if we lose any fundamental research not aimed to answer societal questions? Yes, definitely. Many great inventions

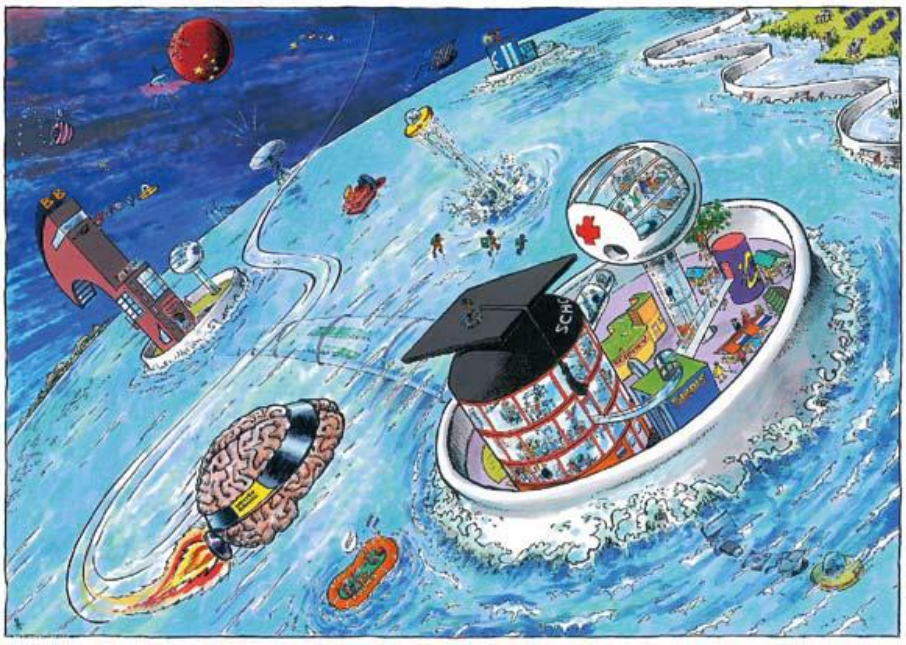
appeared without the aim of any societal benefit (penicillin, electricity etc.), and even the minister seems to agree with this in her letter. I will not go into detail here why basic research not guided by societal questions is relevant as many before me provide convincing answers to this. I freely refer to:

- Curiosity creates cures: The value and impact of basic research, National Institute of General Medical Sciences, National Institutes of Health.
- ICSU position statement: The value of basic scientific research", International Council for Science, December 2004.
- Liz Karagianis - MIT Spectrum (21 April 2015). "How discovery science is reinventing the world - MIT News". MIT News.
- Karen Kashmanian Oates – The Importance of Basic Research – Huffington Post

If you are not convinced of the role of basic research I would like to see you try to solve cardiac arrest without knowing how the heart works in the first place. The point that is important here is that there is no logical way to infer which knowledge will be relevant in the future and which knowledge will not be relevant. At what level of processing should we know all details of the heart to solve all heart diseases? Is the level of arteries enough, or should we go for the level of genes, or single atoms? Who knows what level will be sufficient? (see also a great and entertaining discussion at the cognitive neuroscience meeting 2016 about a related topic: https://www.youtube.com/watch?v=uSbNRyY2QH0). Is the researcher investigating the blood flow in the left anterior descending artery required to develop the cure for cardiac arrest? I say no, this person is merely obliged to share his knowledge within the community so that we know how this detailed piece of knowledge could aid in figuring out heart functioning as a whole.

Reflection: Knowledge has to circulate

In 2009 another beautiful document appeared from the government (Van voornemens naar voorsprong: Kennis moet circuleren). They created a vision what valorization would bring us in 2016. The following picture provided their vision. I leave this up for your own interpretation.



Now, we are in 2016. So this is the perfect time to reflect on valorization as it is implemented. What has valorization in universities brought? Of course not much that this picture provides (although I would have liked to have a flying brain), but I guess that could have been expected in 2009. Valorization as it is implemented now forces PhD students to think about how their research is relevant for society in a five-to-eight page document at the end of their thesis. It forces bachelor students just learning about research for the first time to report on the relevance of their intended research. So already during their studies they are drilled that research is about societal questions. It requires every grant application to contain speculations and operationalizations of the possible impact of our research even if we are not qualified at all to actually implement the possible societal relevant output. Finally, less and less funding is available for fundamental research.

Are there only bad consequences of valorization? No, I think there are some clear positive changes that we should focus on. I think the main positive sign that is happening is focusing on the "*availability*" of knowledge. This is in the end the core of valorization for fundamental research to me. The Dutch government has been pushing publishing

agencies to publish research "open access". This means that anybody can access your publication, instead of letting universities pay for specific journals, by which the normal public does not have any access. Moreover, many journals have been pushing you to rephrase your research findings in layman's language. Although I would prefer that they call these sections "Layman's message" instead of "significance", they still provide a means to have a better understanding of the main message of a paper. These advances make it possible for societal or business partners to *use* the created knowledge. Knowledge exchange might be one of the core problem is modern-day science. We scientists have specialized knowledge about one small fraction of science. The exchange of this knowledge is still very difficult. Especially considering that different research fields are speaking with their own language. It is necessary to invest in ways to improve communication with each other.

I fully agree that knowledge is there to be exchanged, indeed to circulate. However, let the different parties do what they are experts in. Basic scientists to create knowledge; applied scientists, businessmen and societal institutions to use this knowledge and implement it for products, programs etc. (also read about why many researchers unconsciously are busy with valorization in the first place https://pure.knaw.nl/portal/files/1514072/Hoe_onderzoekers_werkelijk_valoriseren.pdf). Let us focus on the exchange between these different groups instead of forcing basic scientists to perform all these steps. Create transparency and a platform to exchange knowledge at a suitable level such that qualified people get the relevant knowledge (the suitability level would vary according to the background knowledge of the exchanging parties. The one provided in this section would of course not suit many applications much more than my mom understanding a bit better what I do). Leave space (and funding) for basic research that has no direct societal influence and leave the research questions to the scientists and the implementation of knowledge to the implementers (which of course can include qualified scientists). Maybe then we can create our flying brain in 2025.