The HealthPAC project received its funding from the EU 7th Framework Programme Marie-Curie FP7-PEOPLE-2013-ITN under IDP Grant agreement nr. 604063

Name ESR and number in HP: Elahe Arani, ESR03
Nationality: Iranian
Research work-package: WP5 (SEE)

Starting date ESR: 15 Apr 2014
Supervisor and co-supervisor: Prof. Richard van Wezel, Prof. John van Opstal
Host-institution - Department: DCN, Biophysics department, Radboud University

RESEARCH

RESEARCH PROJECTS AND RESULTS FROM **01/01/2014** UNTIL **31/12/2017** ***(use 1-2 pages)***
(for each project give title, its goal(s), the main results and conclusions, with a representative photo/figure which we can use on the Website!
Indicate, where appropriate, Milestone/Deliverable number (see Annex 1 pp 25-26)

Project 1: **Aging: a window into neural processes of visual perceptual decisions**

The strong growth of the aging population will be accompanied by increasing numbers of people suffering from age-related dysfunctional cognitive processes. Understanding the underlying mechanisms of age-related cognitive decline is therefore essential in our aging society. Earlier studies have demonstrated slower cognitive processes in older adults. An important fundamental cognitive process that changes with age is visual perceptual decision making. However, the neurobiological mechanisms underlying these age-associated changes are still unclear. We approach this problem by studying age-dependent perception of bistable visual stimuli, because much is known about the underlying mechanisms of bistable perception. Bistable perception is a phenomenon in which perception switches between two rivaling interpretations of an unchanging stimulus. Perceptual rivalry of ambiguous figures, such as the Necker cube, leads to alternations between two possible pictorial interpretations, whereas binocular rivalry involves perceptual alternations between competing monocular images. Several neurobiological factors play a key role in binocular and perceptual rivalry: adaptation of neural populations coding for the two different percepts, cross-inhibition the two competing neural populations, as well as noise. Previously, it has been shown that older adults compared to young adults experience longer switch durations for perceptual rivalry and for binocular rivalry. However, the role of adaptation, cross-inhibition and noise are still unclear. To address this, we studied the effect of aging on both perceptual and binocular rivalry in different presentation conditions. Two age groups of participants reported their spontaneous percept switches during continuous and percept choices during intermittent presentations. Our results showed no significant age effect on the mean and cumulative frequencies of percept switch durations under continuous presentation. Interestingly, the data revealed that the alternation rate for percept choices under intermittent presentation significantly decline at an older age. The latter effect is even more pronounced at shorter inter-stimulus durations. These results together with the predictions of existing neural models for bistable perception imply that age-dependency in visual perceptual decisions are caused by reduced neural adaptation and noise, but not a change in inhibition strength. Our results show that changes in low-level aspects such as neural adaptation and noise could be related to cognitive decline.

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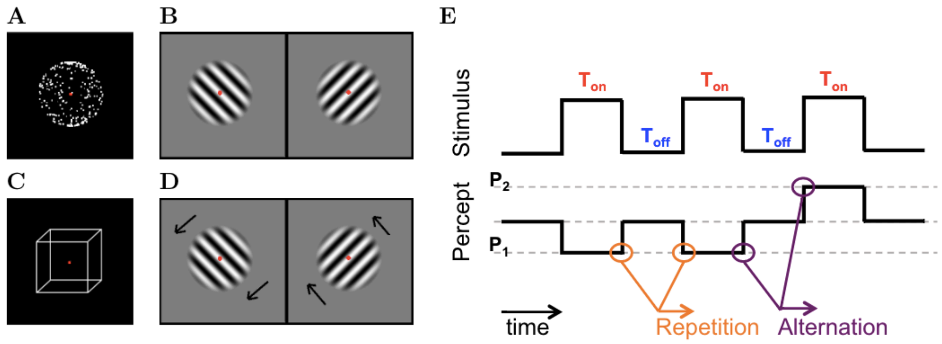

Figure 1. **Visual stim*uli and experimental procedure.*** Stimuli: (A) structure from motion (SFM) sphere, (B) binocular rivalry of static gratings presented in the left and right eye, (c) Necker cube, and (D) binocular rivalry of drifting gratings presented in the left and right eye. (E) Experimental procedure for the percept choice condition: stimuli were presented intermittently with various inter-stimulus durations (upper panel) for one-second stimuli duration. During each stimulus presentation, the participants reported the perceived percept (lower panel). Two subsequent similar percepts are defined as a repetition, and two subsequent different percepts are defined as an alternation.

Project 2: Age-dependency in visual perceptual decisions caused by variation in adaptation and noise, but not in inhibition strength

Some aspects of decision-making are known to decline with normal aging. To understand how age affects visual decision-making, we investigated age-related changes in perception during binocular rivalry (BR). In BR, the image presented to one eye competes with that presented to the other eye in order to achieve perceptual dominance. Perception during BR consists of alternations between exclusive percepts, however sometimes mixed percepts become more prevalent. In the first experiment, 52 participants, ranging from 17 to 72 years old, viewed rivalry stimuli and they were forced to make a choice between exclusive percepts. Stimuli were presented intermittently for 1 second, with a range of inter-stimulus intervals (0.125 – 2 seconds). The results of this percept choice experiment show that perceptual alternations decrease at an older age. During the same experiment participants also passively viewed prolonged presentation the same BR stimuli and participants were instructed to report each percept switch. The results of those measurements show that mean percept durations increase with age. The results of these experiments show that younger participants have more alternations, so we hypothesized that young participants will experience more mixed percepts as a result of weaker inhibitory efficacy. To investigate that, in the second experiment, we instructed 23 participants divided into two age groups (average: 21.5 and 59.3 years old) to report both exclusive and mixed percepts during the intermittent stimulus presentation for the same setting as in experiment 1. In addition to a decrease in perceptual alternation rate for the older group, the proportion of mixed percept also decreased for the older participants. However, the results show that during prolonged exposure to BR stimuli, the proportion of mixed percepts among young and old participants is not significantly different. Our data and analyses suggest that differences in synaptic depression can simulate the aging aspect of perceptual decisions in BR and not differences in parameters related to adaptation and/or gain modulation at the input level.

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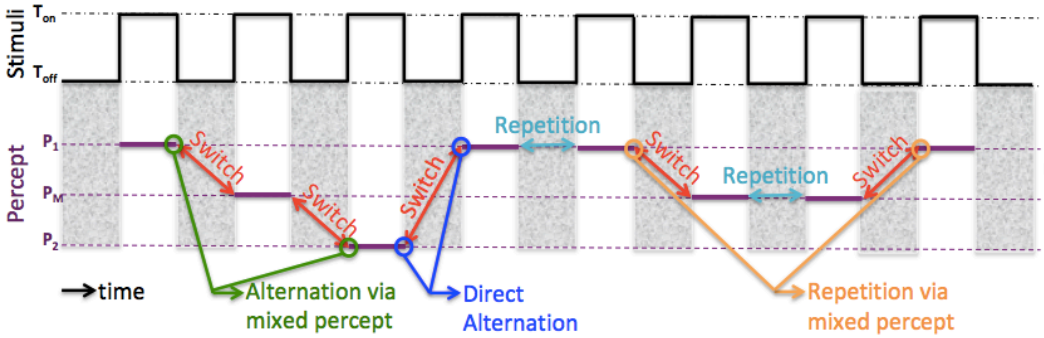

Figure 2. Experimental procedure for the percept choice condition: stimuli were presented intermittently with various inter-stimulus durations (upper panel) for one-second stimuli duration. During each stimulus presentation, the participants reported the perceived percept (lower panel). Two subsequent similar percepts are defined as a repetition, and two subsequent different percepts are defined as a switch.

Project 3: Reverse engineering neural networks from many partial recordings

Much of neuroscience aims at reverse engineering the brain, but we only record a small number of neurons at a time. We do not currently know if reverse engineering the brain requires us to simultaneously record most neurons or if multiple recordings from smaller subsets suffice. This is made even more important by the development of novel techniques that allow recording from selected subsets of neurons, e.g. using optical techniques. To get at this question, we analyze a neural network, trained on the MNIST dataset, using only partial recordings and characterize the dependency of the quality of our reverse engineering on the number of simultaneously recorded "neurons". We find that reverse engineering of the nonlinear neural network is meaningfully possible if a sufficiently large number of neurons is simultaneously recorded but that this number can be considerably smaller than the number of neurons. Moreover, recording many times from small random subsets of neurons yields surprisingly good performance. Application in neuroscience suggests approximating the I/O function of an actual neural system; we need to record from a much larger number of neurons. The kind of scaling analysis we perform here can, and arguably should be used to calibrate approaches that can dramatically scale up the size of recorded data sets in neuroscience.

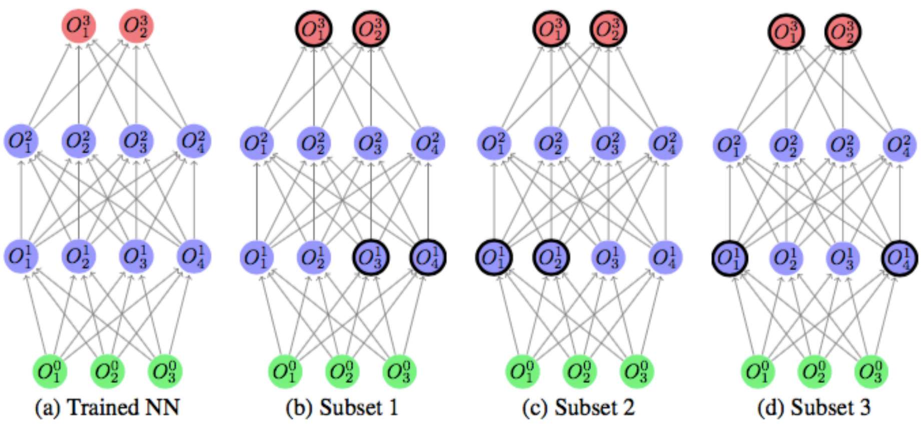

Figure 3. An example of three recording subsets. (a) The ground-truth neural network. (b,c,d): An example of three subsets. In each subset, the output neurons and two of the neurons of layer 1 are observed. Observed neurons are outlined in black.

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OUTREACH ACTIVITIES

OUTREACH ACTIVITIES FROM 01/01/2014 UNTIL 31/12/2017

(mention your public presentations on open days, participation in general public events, press, etc. etc.: when, what and where).

Your publications: those that have been submitted/published (provide all bibliographic details), and those that you are currently finishing: give title, and foreseen journal, if possible)

Are there any patents? New foreground? Applications for the general public/society?

- **Public presentations:**
  - Brain Awareness Week 16-22 March 2015
  - Demos to industrial visitors and public (high-school students)
- **Publications:**
  - E.Arani, R.vanEe, R.vanWezel, "Aging: a window into neural processes of visual perceptual decisions", (to be submitted to Current Biology).
  - E.Arani, S.Triantafillou, K.Kording, "Reverse engineering neural networks from many partial recordings", (in preparation).
  - E.Arani, R.vanEe, R.vanWezel, "Age-dependency in visual perceptual decisions caused by variation in adaptation and noise, but not in inhibition strength", (in preparation).
  - E.Arani, R.vanWezel, "Dynamics of visual perception changes by different psychiatric disorders", (in preparation).

TRAINING ACTIVITIES

TRAINING ACTIVITIES FROM 01/01/2014 UNTIL 31/12/2017

describe your courses (received and given), (summer)schools, and your Secondments: when, what, and where

- Courses:
  - Optimizing Cognitive Functioning
  - Psychophysics I: Auditory perception in Health and Disease
  - Psychophysics II: Motor control in Health and Disease, Sensorimotor integration
  - Neuroimaging Toolkit: Neuroimaging (fMRI, EEG, MEG)
  - Bayesian Modeling for Cognitive Science
- Teaching:
  - BFCA_NLT_Cluster_Nijmegen_2014-2016
  - Psychophysics I: Auditory perception in Health and Disease
  - Neuroscience: van basis tot kliniek - BFCA_NLT_Cluster_Nijmegen_2015-2017
- Summer-school:
  - HealthPAC Summerschool_CoSMo, The Netherlands, Jun-Jul 2015
- Secondment
  - Northwestern University, Chicago, USA, Nov-May 2017

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CONFERENCES
CONFERENCES, WORKSHOPS FROM 01/01/2014 UNTIL 31/12/2017 ***(mention which conferences and workshops you have attended: when and where)***
- Workshop on Motor Learning and Control, The Netherlands, Mar 2015 (giving a talk) - Eye movement-GRC conference, USA, Jul 2015 (presenting poster) - NETT International Conference on System Level Approaches to Neural Engineering, Spain, Sep 2015

FUTURE CAREER PLANS
Describe your future career plan(s), after the end of the project. Note: the PhD is obtained *after* HP (31/12/2017!), so it's part of the future career plan. What are your career plans after obtaining your PhD?
First and foremost, I am planning on getting my PhD degree. To do so, I try to finalize the four publishable chapters and put them together as a PhD thesis, and then arrange my PhD defense meeting. My long-term goal is to stay in academia and set-up my own lab. I would, therefore, start looking for good Postdoc positions. Having worked on some exciting and new research projects in this program, I am optimistic that I will be able to pursue my scientific career further.