MSc in Computational Cognitive Neuroscience

Goldsmiths
UNIVERSITY OF LONDON

Modelling melodic long-term working memory using a novel melodic production task and big data approaches

Sebastian Silas, Daniel Müllensiefen, Tim Blackwell

Background

Working memory (WM), the ability to hold information in short-term memory and manipulate it in real time, seems particularly relevant to musical behaviours. However, some authors find that Baddeley's popular (1983) psychological WM model does not explain memory for musical stimuli. Therefore, it is not clear whether musical stimuli require a separate "slave" system and/or different functional processes to general WM. A possible resolution was posed by Ericsson & Kintsch (1995) who argued that the acquisition of expertise represents the development of a qualitatively different memory system to general WM, which they named **long-term WM**, whereby long-term memory supports WM and relies on domain-specific training. However, Baddeley's (1974) original model already suggested that long-term and short-term memory were unitary systems and that WM could access items stored in long term memory. Consequently, WM can be used as a proxy for long term memory: one can demonstrate long-term knowledge transiently in WM. However, the additional implication of long-term WM theory is that WM performance, particularly relevant to musical behaviour, should vary as a function of domain-specific expertise.

The current project

We are interested in studying individual differences in long-term memory for musical melodies, how WM reveals knowledge states transiently, and how both vary as a function of expertise. Since musical training involves the deliberate acquisition of mental representations which enable the handling of musical phenomena, it should also enable the ability to hold longer and more complex melodies through the "chunking" together of meaningful patterns based on representations stored in long-term memory.

To simultaneously make inferences about long term memory and cognitive processes using behavioural measures, we must circumvent limitations with typical psychometric methodology which traditionally produces dichotomous, polytomous and continuous scores and is not based on the principle of cognitive processes that unfold across time. Therefore, we have designed a task which captures melodic production, actions recorded at the millisecond degree, as generated by participants. The production task should allow the assessment of long-term WM by considering generated actions as proxies for both cognitive processes and long-term memory for psychological stimuli.

Task Development

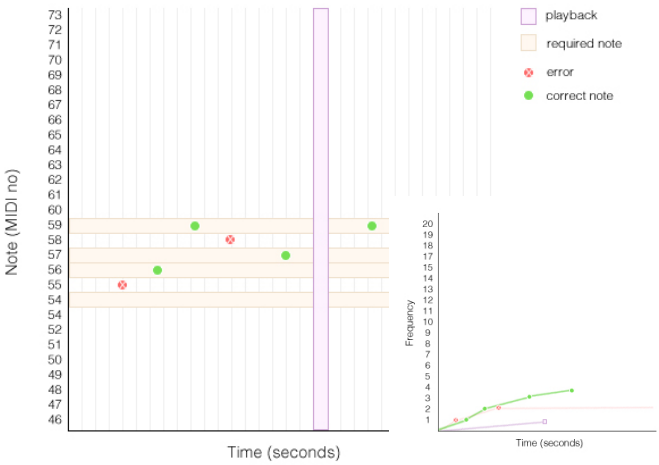
Melody Singing Task

We created a task to capture melodic production, specifically here for the purpose of melodies which are sung back.

Pitch Discrimination Task

We reimplemented Sorzano & Grassi's (2014) complex tone discrimination task in R Shiny.

Figure 1. Example Melody Singing Task output



Data Collection 1. w/ battery of musical & WM tasks

We are collecting ~100 participants data on our new tasks, self-reported musical training, singing ability and demographics plus: Pitch Imagery Arrow Task, Melodic Discrimination Task, Mistuning Perception Test, Digit Span and a visuospatial WM task.

Data Collection 2. Large sample for big data analysis

We are collecting ~300 participants data singing back *arrhythmic* melodies plus self-reports of musical training and singing ability.

Analysis 1. Expertise assessment (replication study)

Behmer, Lawrence, & Crump (2016) assessed how the performance of sequencing in typists changes as a function of expertise and natural language statistics. We will replicate this in our musical production task context and expect a similar result with task performance being predicted by musical N-grams and expertise level.

Analysis 2. Validation study

We will assess how tasks in the first battery relate to each other. Using factor analysis, structural equation modelling and causal modelling techniques, we will assess if any broad domains of variance emerge between tasks. A key goal is to delineate singing ability from a melodic cognition ability. Based on Analyses 1 and 2, we will construct an explanatory cognitive processes model.

Analysis 3. Recurrent neural network prediction

Based on representing a melody as a pitch vector (plus other predictors), we will train a LSTM or GRU neural network to try and forecast for an individual: **a)** total trial time, **b)** response patterns**, c)** pitch accuracy and **d)** no. of playbacks. Can this descriptive model provide more accurate predictions than our explanatory model?

Citations
Baddeley & Broadbent (1983); Berz (1995); Behmer, Lawrence & Crump (2016); Chang, Cheng, Allaire, Xie & McPherson (2020); Sorzano & Grassi, (2014)