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Adaptive music recognition games for Dementia therapy

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ABSTRACT

Background

In partnership with the Manchester Museum of Science and Industry, the Wellcome Trust, and the Manchester City Council, Burgoyne et al. (2014) created Hooked on Music, a citizen-science experiment on long-term musical memory.[1] It takes the form of a timed music recognition game requiring no knowledge of music trivia, only an accurate auditory image. It is currently a static experiment, drawing uniformly for each participant from a sample of popular commercial recording fragments, but it relies on a similar game-scoring rule that powers recent developments in item-response theory for exploiting reaction times in computer-adaptive testing (Maris & Van der Maas, 2012).

Aims

We are investigating whether these developments could work to make Hooked on Music adaptive, predicting the most memorable fragments per participant and updating those predictions with every new play. If so, the game could be extended toward a therapeutic tool for dementia. Dementia patients benefit from personalised music therapy using familiar music (Gerdner, 2005; Sacks, 2007), but when these patients struggle to communicate verbally, it is difficult to identify what music best triggers memories. Because Hooked on Music is a strictly musical game, an adaptive version might be able to help caregivers overcome this verbal communication barrier. Before moving into the dementia community, however, it is important first to confirm that the adaptive approach can work in a healthy population and yield results comparable to the original experiment.

Main Contribution

The first Hooked on Music data have been analysed with linear ballistic accumulators (LBA), a variant of the classical drift-diffusion model (Brown & Heathcote, 2008). This model takes into account some differences between individuals and yields precise estimates of recognisability, but it is too computationally intensive to be practical for adaptive updating. The recognisability estimates from LBA correlate positively, however, with the difficulty estimates from two simpler item-response models – *signed residual time* (Maris & Van der Maas, 2012) and *item-response trees* (Partchev & De Boeck, 2012) – which are practical for on-line adaptation.

Moreover, Van Balen et al. (2015) have developed a technique for uncovering the relative effects of melody, harmony, and timbre on the LBA recognisablity results, a technique which can also provide vector-valued difficulty ratings for seeding multidimensional variants of the aforementioned item-response models. With multidimensional item-response models, Hooked on Music could make more refined matches between musical fragments and participants and provide explicit estimates of participants' preferred musical recall strategies (melodic, harmonic, or timbral).

Hooked on Music has been played over 2 million times by more than 120 000 participants and remains popular. In tandem with the Manchester Science Festival 2015, we will replace the back-end of Hooked on Music to incorporate item selection according to a multidimensional item-response model. Difficulty estimates will be fixed according to the LBA analysis of previous data and participants' abilities will be estimated adaptively as they play. With this new back end, we will be able to evaluate how effectively Hooked on Music could be used to personalise playlists for maximal recognition.

Implications

Although the drift-diffusion family is the traditional best-of-class approach for analysing reaction times, item-response models can recover the same underlying phenomenon with the added benefit of real-time adaptivity. Therapeutically, such adaptivity could identify personalised playlists, a particular advantage for dementia patients who struggle to communicate verbally.

Keywords

Dementia, memory, music therapy, item-response models, reaction times

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