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Becoming a pianist: an fMRI study of musical literacy acquisition

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Abstract

Musically naïve subjects were scanned using functional magnetic resonance imaging (fMRI) before and after they had been taught to read music and play keyboard. When subjects played melodies from musical notation after training, activation was seen in a cluster of voxels within the right superior parietal cortex consistent with the view that music reading involves spatial sensorimotor mapping.

Keywords: pianist; fMRI; musical literacy

Introduction

When a child or adult starts to play the keyboard, a significant part of the initial musical training is devoted to learning to read musical notation. Musical pieces that at first sight, appear meaningless in their written form will eventually be translated into a recognizable melody. Just as written language becomes meaningful and even compelling to read, so does musical notation. A key question is how the artificial process of sight-reading for keyboard performance becomes a natural process. How do brain areas become recruited for such a skill? The advent of functional magnetic resonance imaging (fMRI) has permitted longitudinal studies of the neural correlates of skill acquisition. Music reading is a skill that lends itself to such an approach, because only a small fraction of the population is musically literate and many are motivated to learn. Thus, a unique opportunity exists for investigating the acquisition of an artificial and culturally valued skill. The following represents a brief account of a study that was designed to look at music reading in a learning context.¹

Material and methods

Training: Subjects attended a 90-minute music lesson once a week for 15 weeks. Practical keyboard skills and music theory were taught to Grade 1 (Associated Board, UK) level.

Tasks used during scanning: (1) Explicit Music Reading Task (fig. 1). This task required subjects to produce a series of keypresses in response to the appearance of a sequence of five musical notes. Before training, subjects used the superimposed numbers to play the sequences; after training, they relied solely on the musical notation. (2) Implicit Music Reading Task (fig. 2). The task was identical before and after training. Subjects indicated whether the target (a single vertical line that extended above or below the five horizontal lines of the staff) was ascending or descending, using an arbitrary up/down mapping to the index and middle fingers.

Statistical Analysis. The explicit and implicit music reading tasks were analyzed separately for the pre-training and post-training sessions using statistical parametric mapping software (SPM99, Wellcome Department of Cognitive Neurology).

Statistical Parametric Mapping Software. Random effects analysis was used to isolate training-related activations (greater activation for experimental trials versus control trials, post-learning versus pre-learning).

Results

Learning to Play a Melody: Explicit Music Reading Task. A training effect was seen in right superior parietal cortex (fig. 3). Examination of the mean percentage signal change for the maxima of this region revealed a trial effect that, although significant before training, was even greater after training.

Effect of Exposure to Musical Notation: Implicit Music Reading Task. A training effect was seen in the left supramarginal gyrus, left inferior frontal sulcus, and right frontal pole (fig. 4). Examination of the mean percentage signal change for the maxima of these regions revealed that all voxels exhibited the same relative pattern: a trial effect that was restricted to the post-training session.

Activations Common to Both Explicit and Implicit Music Reading. Inclusive masking revealed common training effects across the explicit and implicit music reading tasks in the bilateral superior parietal cortex, media superior parietal cortex, and left postcentral gyrus.

Discussion

Learning to Play a Melody: Explicit Music Reading Task. The dorsal visual processing stream, within which the superior parietal cortex resides, is known to be important for coding of spatial as opposed to featural aspects of visual stimuli (the “what”/“where” distinction).² A distinction has also been made between the visual perception of objects versus the control of action towards those objects (the “what”/“how” dichotomy).³ Whether the distinction made is one of “what versus where” or “what versus how,” sight-reading for keyboard performance falls within the class of behaviours that the dorsal stream is known to subservise. First, the information relevant for performance is contained in the position of the note on the staff (“where”); second, musical performance relies on the use of this positional information to guide selection of the appropriate keypress (“how”). Note that our finding corresponds well to those of Sergent et al.⁴ that relate to a PET study of sightreading in professional pianists, suggesting that they may be independent of skill level.

Fig. 1. **Explicit Music Reading Task.** The explicit music reading task was different pre-training versus post-training.



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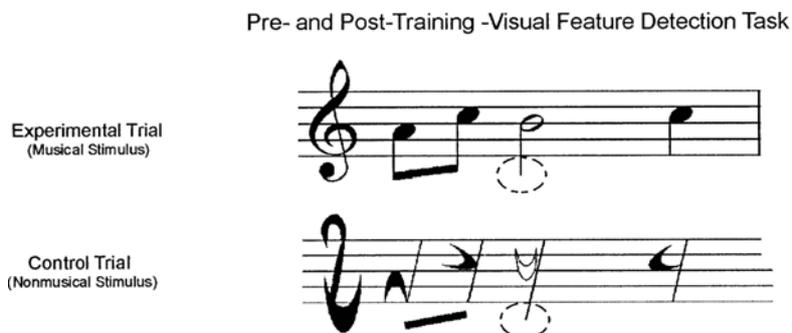


Fig. 2. **Implicit Music Reading Task.** The implicit music reading task was identical pre- and post-training.

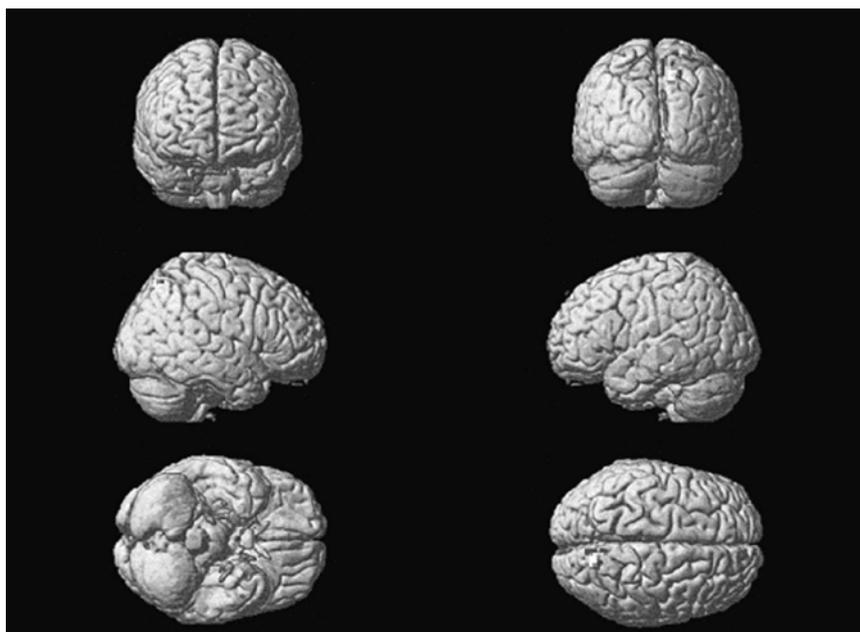


Fig. 3. **Explicit music reading.** Statistical parametric map rendered onto a normalized structural image, showing activation that was greater for note to note finger mapping (post-training) than for number to number mapping (pre-training) for experimental trials minus control trials. Activation was seen in right superior parietal cortex.

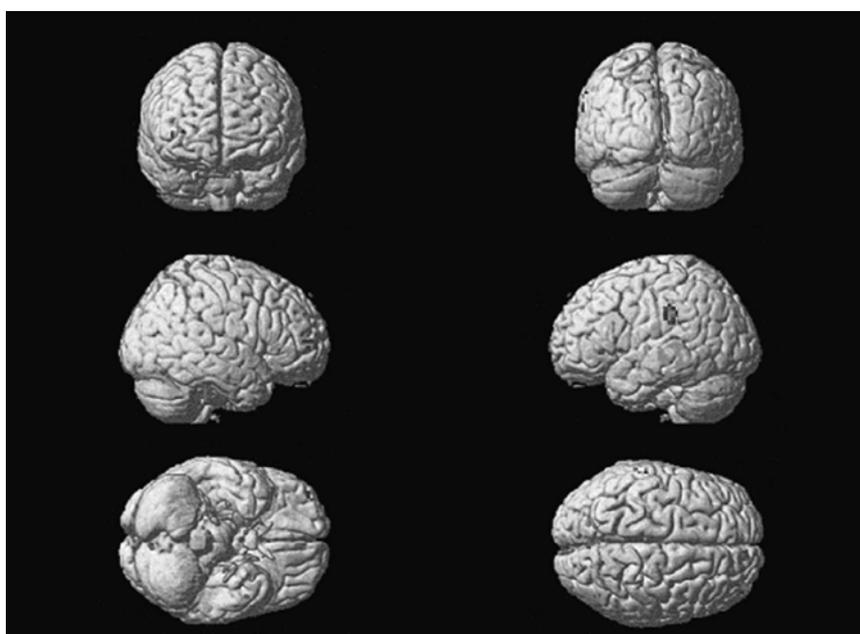


Fig. 4. **Implicit Music Reading.** Statistical parametric map rendered onto a normalized structural image, showing activation that was greater post-training than pre-training for experimental trials minus control trials. Activation was seen in left supramarginal gyrus, post-central sulcus, medial parietal cortex, right cerebellum, and right frontal pole.