Interactions with musical long-term memory are a critical component of musical working memory

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Introduction & Aim

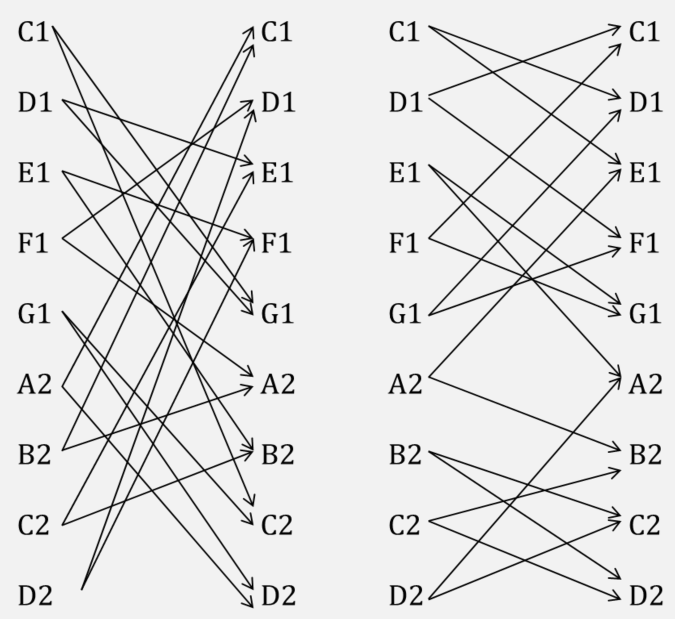
Working memory (WM) has been extensively studied particularly in the verbal domain. These studies demonstrate strong links between WM and long-term memory (LTM) knowledge and suggest that LTM-WM interactions are a fundamental principle of WM (Gathercole et al., 1995 ; Majerus et al., 2012). The aim of this study is to provide further evidence for this pinciple, by showing that musical WM, like verbal WM, is grounded in LTM musical knowledge.

We conducted three experiments assessing the impact of implicitly learnt musical knowledge via an artificial musical grammar learning paradigm on subsequent WM for musical stimuli. The first two studies used implicit learning grammars with different levels of familiarity allowing us to further evaluate the impact of sequence familiarity on musical WM performance. Finally, a third experiment assessed the impact of musical expertise on musical WM.

Methods

Participants

Experiment 1 : 16 adults without musical training or experience
Experiment 2 : 14 adults without musical training or experience
Experiment 3 : 11 amateur musician adults with regular musical training and activities



Experiment 1 & 3 (less familiar) — Experiment 2 (more familiar)

Implicit musical learning task

The participants were first confronted to an implicit learning task for tone transition rules. They were asked to complete a complex drawing task while passively listening to a continuous sequence of 3795 tones governed by an artifical grammar (fig. 1 & 2) presented as a noise distractor.

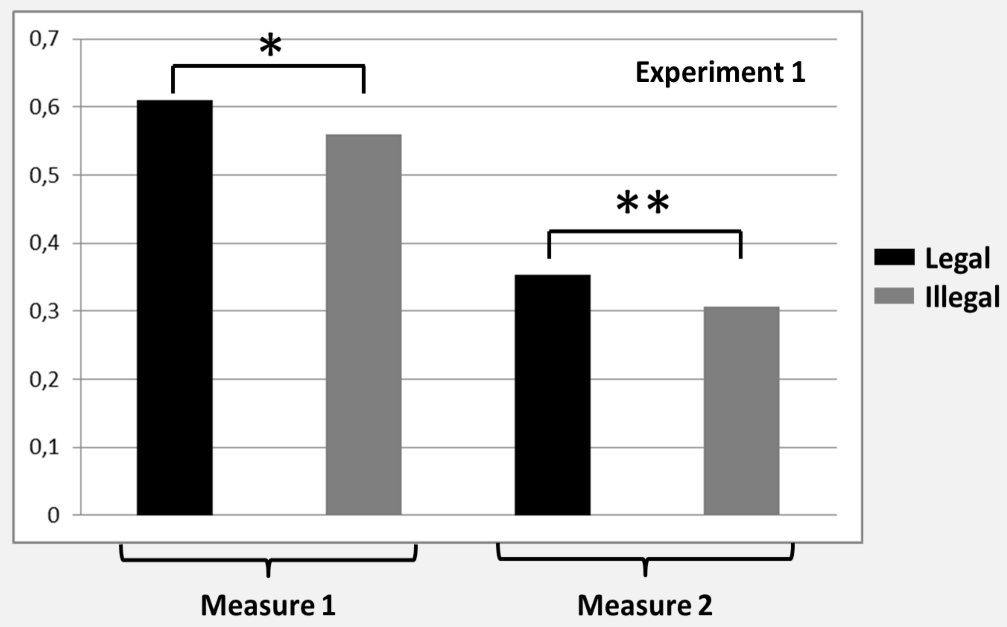
WM task: short-term reproduction of tone sequences

- Immediate serial recall of tone sequences of increasing length (2 to 10 items & 3 trials per length)
- Half of the sequences followed the same transition rules as those embedded in the artifical grammar (legal sequences) ; the other half was illegal
- Reproduction by humming

Scoring

For all sequences, each tone sequence produced by the participant was compared on a tone-by-tone basis relative to the target sequence. A backward and a forward scoring procedure was used and the best score was retained as the dependent variable. Using this procedure, we scored : 1) the up-down patterns of two succeeding tones (M1) ; 2) the up-down patterns of two succeeding tones considering in addition interval difference accuracy within a limit of +/- 200 cents (M2).

Results

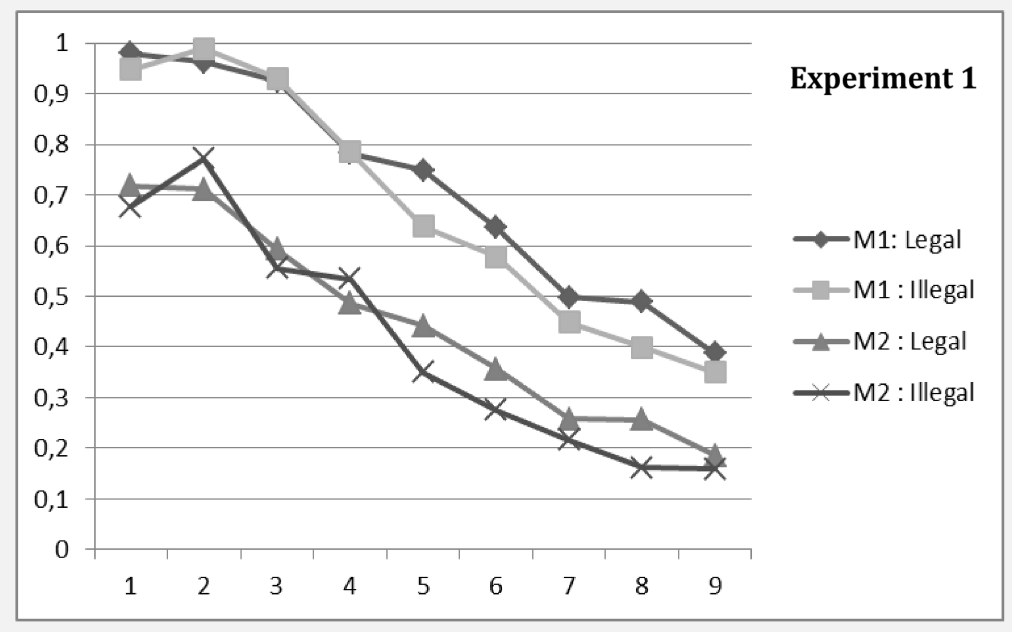


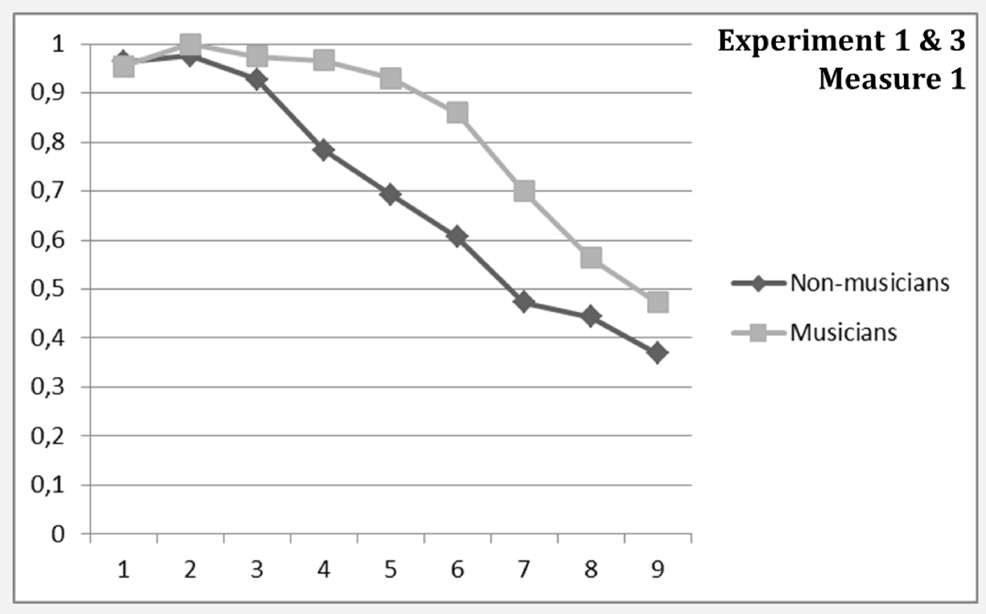
Mean recall performance

Effect of condition:
Exp. 1
M1 ➔ $t(15) = 2.83$, $p = \mathbf{.013}$
M2 ➔ $t(15) = 3.90$, $p = \mathbf{.001}$
Exp. 2
M1 ➔ $t(13) = -1.03$, *n.s.*
M2 ➔ $t(13) = -1{,}31$, *n.s.*
Exp. 3
M1 ➔ $t(10) = 0.51$, *ns.*.
M2 ➔ $t(10) = 0.77$, *n.s.*

Mean recall performance as a function of list length

Effect of condition:
Exp. 1
M1 ➔ $F(1, 15) = 6.20$, $p = \mathbf{.025}$
M2 ➔ $F(1, 15) = 8.89$, $p = \mathbf{.009}$
Exp. 2
M1 ➔ $F(1, 13) = 0.42$, *n.s.*
M2 ➔ $F(1, 13) = 1.39$, *n.s.*
Exp. 3
M1 ➔ $F(1, 10) = 0.99$, *n.s.*
M2 ➔ $F(1, 10) = 0.0001$, *n.s.*





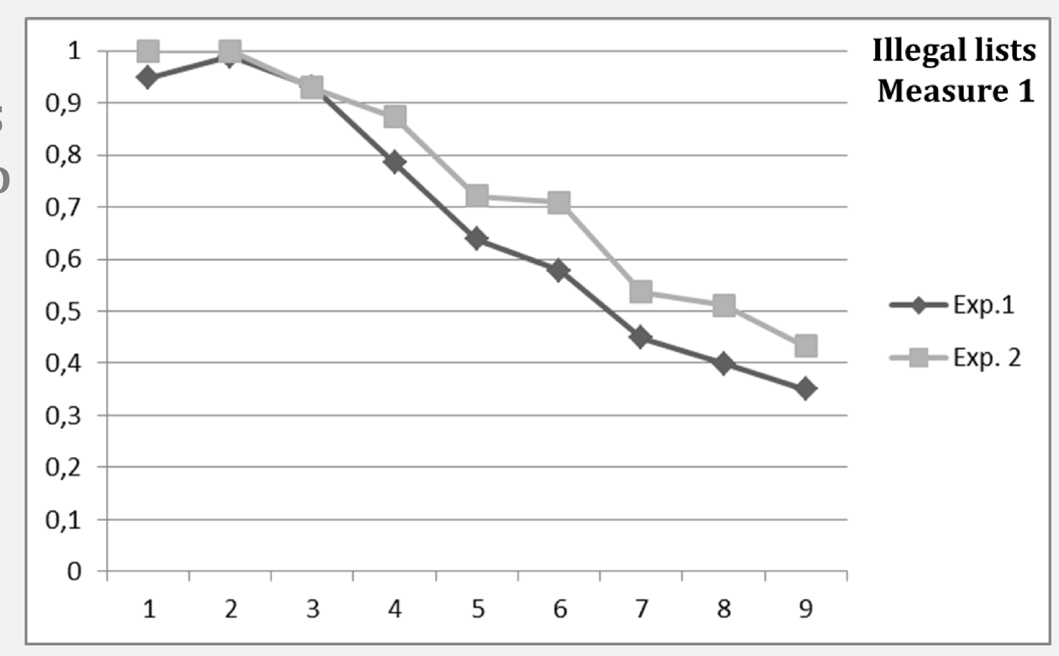
Mean recall performance as a function of list length and group (Exp. 1 & 3)

Effect of group:
M1 ➔ $F(1, 25) = 19.77$, $p < \mathbf{.001}$
M2 ➔ $F(1, 25) = 13.43$, $p = \mathbf{.001}$

*Interaction effect (length*group):*
M1 ➔ $F(8, 200) = 4.36$, $p < \mathbf{.001}$
M2 ➔ $F(8, 200) = 2.37$, $p = \mathbf{.018}$

Mean recall performance as a function of list length and familiarity for illegal lists (Exp. 1 & 2)

Effect of group:
M1 ➔ $F(1, 28) = 4.52$, $p = \mathbf{.042}$
M2 ➔ $F(1, 28) = 38{,}83$, $p < \mathbf{.001}$



Discussion

These results are the first to demonstrate an interaction between musical knowledge stored in LTM and performance in WM for musical stimuli. A significant difference in favor of legal lists was observed in Experiment 1 indicating that participants can take advantage of new musical learning to perform musical short-term recall tasks. Although musician participants showed no difference between performance for legal and illegal lists this is likely to be due to their overall larger familiarity with musical stimuli making statisical learning for new sequences more difficult (Majerus, Martinez Perez & Oberauer, 2012). This is supported by the fact that musician participants outperformed non-musician participants for both legal and illegal lists. Finally, participants performed overall better performance for illegal lists in Experiment 2 which used a more familiar grammar in comparison to the grammar used in Experiment 1 providing further evidence for a reliance of musical WM on musical knowledge.

Overall, these experiments show that implicit learning of new musical structures, musical familiarity and musical expertise support WM for musical stimuli. These results highlight the grounding of musical WM in LTM musical knowledge.

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