The role of musical expertise in circle drawing and finger tapping

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Introduction

Continuous circle drawing and discrete finger tapping are considered emblematic of emergent and event-based timing, respectively. Much research suggests that these two timing processes are dissociable[1, 2] although it has been suggested that both are involved to varying degrees in any timed, repetitive fine motor task[3]. One way to investigate this is to see if the known expertise effects of musical training on event-based timing are also observed in emergent-timing tasks.

❖Musical training should affect both timer and motor aspects of an event-based timing task.

❖Musical training should only affect motor, or duration-independent, variability in an emergent-timing task.

Method

Participants

- 14 musicians (M= 23.0 years old) and 12 non-musicians (M = 21.9), all right-handed
- Years of musical training:
  - Musicians: M= 12.71, SD = 4.03
  - Non-musicians: M = 1.44, SD = 1.34

Apparatus, Task, and Stimuli

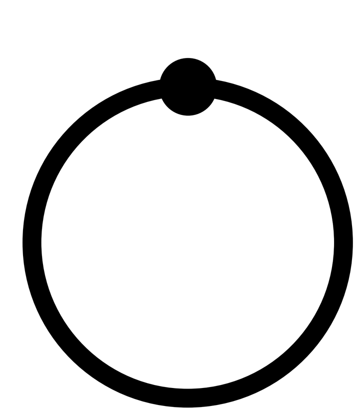
- VZ3000 Visualeyez 3D motion tracking
  - Sampling rate = 200Hz
  - Spatial resolution = 0.015mm
  - LED markers on tip of right index finger (tapping) or on stylus (drawing)
- National Instruments 6221 Data Acquisition board to synchronize mocap with a virtual metronome emitting a 1 KHz 20 ms tone.
- Conditions: Finger tapping or tracing of a 7cm diameter circle on a tabletop at one of 4 different rates: 400, 550, 700, 850 ms.

Procedure

- Grooved Pegboard Task as a measure of speed and fine motor control. No group differences ($t(24) = 1.063$, $p > .05$ for dominant hand speed).
- WAIS Digit Symbol test for measuring processing speed. No group differences ($t(24) = -0.124$, $p > .05$).
- Every participant performed all 8 conditions: tapping or drawing at each of the 4 rates.
- Each condition consisted of 6 trials of 30 paced and 30 unpaced cycles.

Data Analysis

- For both tapping and drawing, we calculated the inter-response interval (IRI) of the unpaced phase.
- Tapping: Using the z-coordinate, automatically detect taps.
- Drawing: Using the x-coordinate, count every second zero-crossing as a circle trajectory.



Results

		Tapping				Drawing			
		400	550	700	850	400	550	700	850
Musicians	Mean	398.0	544.2	680.4	829.3	343.8	490.9	577.1	656.3
	StDev	6.1	9.4	10.6	14.5	68.9	109.0	111.7	178.7
Nonmusicians	Mean	395.4	544.2	686.3	835.7	337.6	477.3	518.8	586.9
	StDev	9.0	15.3	14.1	17.9	120.3	252.1	202.2	222.1

Table 1. Mean IRI.

		Tapping				Drawing			
		400	550	700	850	400	550	700	850
Musicians	Mean	24.6	32.3	39.9	60.3	81.5	131.1	164.3	150.9
	StDev	9.4	13.5	13.1	37.4	39.6	117.9	98.7	92.1
Nonmusicians	Mean	36.2	41.2	74.0	76.3	78.8	116.1	130.1	204.2
	StDev	32.2	33.8	64.4	50.3	64.7	106.6	80.3	113.6

Table 2. Mean IRI variability.

Unpaced tapping IRI variability

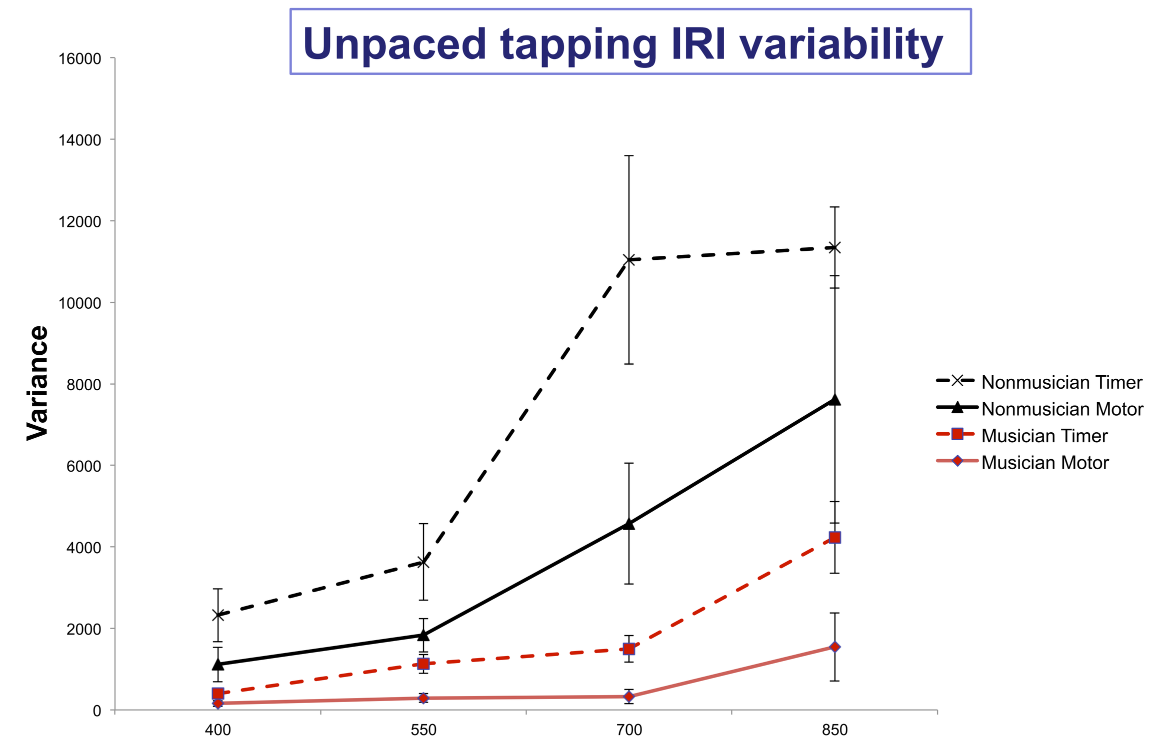


Figure 1. Unpaced tapping timer and motor variability estimated using the Wing-Kristofferson model[4]. Slopes of motor variability lines are not significantly different from zero. No group effect on timer slopes or on pooled motor variability.

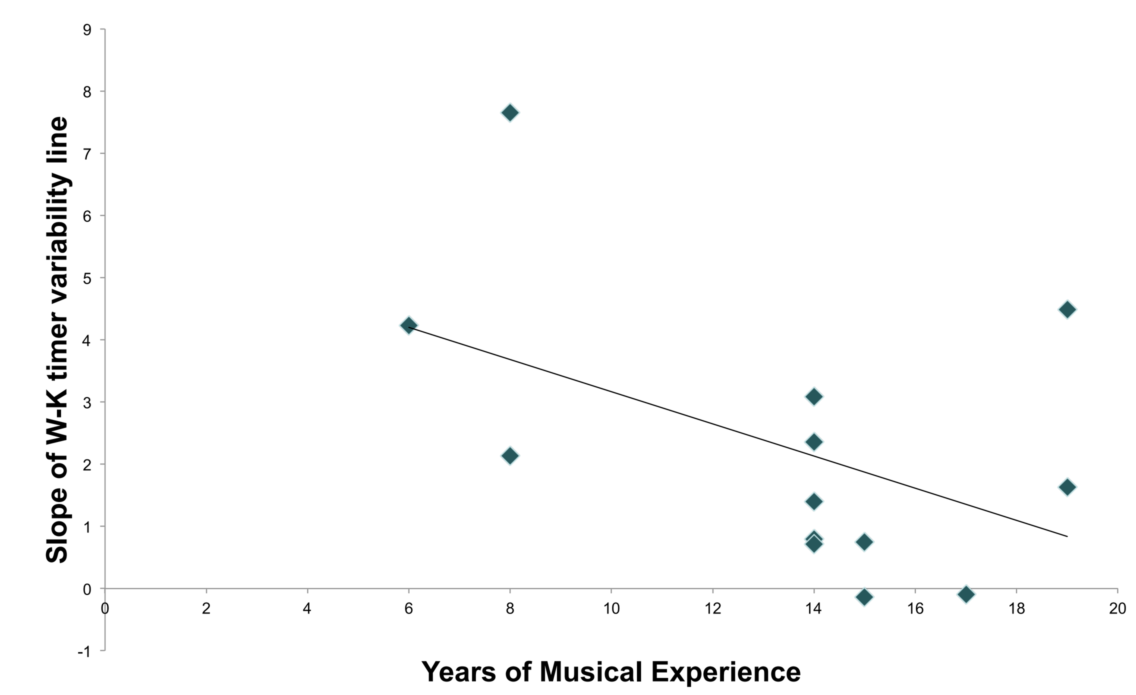


Figure 2. Years of musical experience of musicians plotted against the slope of the Wing-Kristofferson timer variability line. $r = -0.475$, $p = .101$.

The effects of task, rate, and music on IRI variability

- Main effect of task: Drawing is more variable than tapping, $F(1,24) = 52.285$, $p < .001$, *partial* $\eta^2 = .685$
- Main effect of rate: Variability increases as rate slows, $F(3,72) = 11.755$, $p < .001$, *partial* $\eta^2 = .329$
- Task x Rate interaction (Figure 3): Drawing appears to increase in variability more rapidly than tapping, as a function of rate, $F(3,72) = 2.868$, $p < .05$, *partial* $\eta^2 = .107$
- Planned music x task pair-wise comparisons: musicians marginally less variable than non-musicians at tapping ($p = .096$) but no group differences for circle drawing

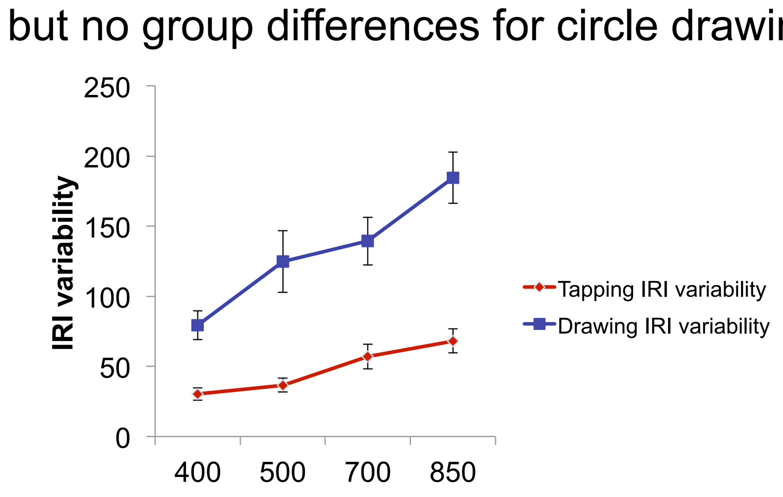


Figure 3. Task x Rate interaction

Slope analysis

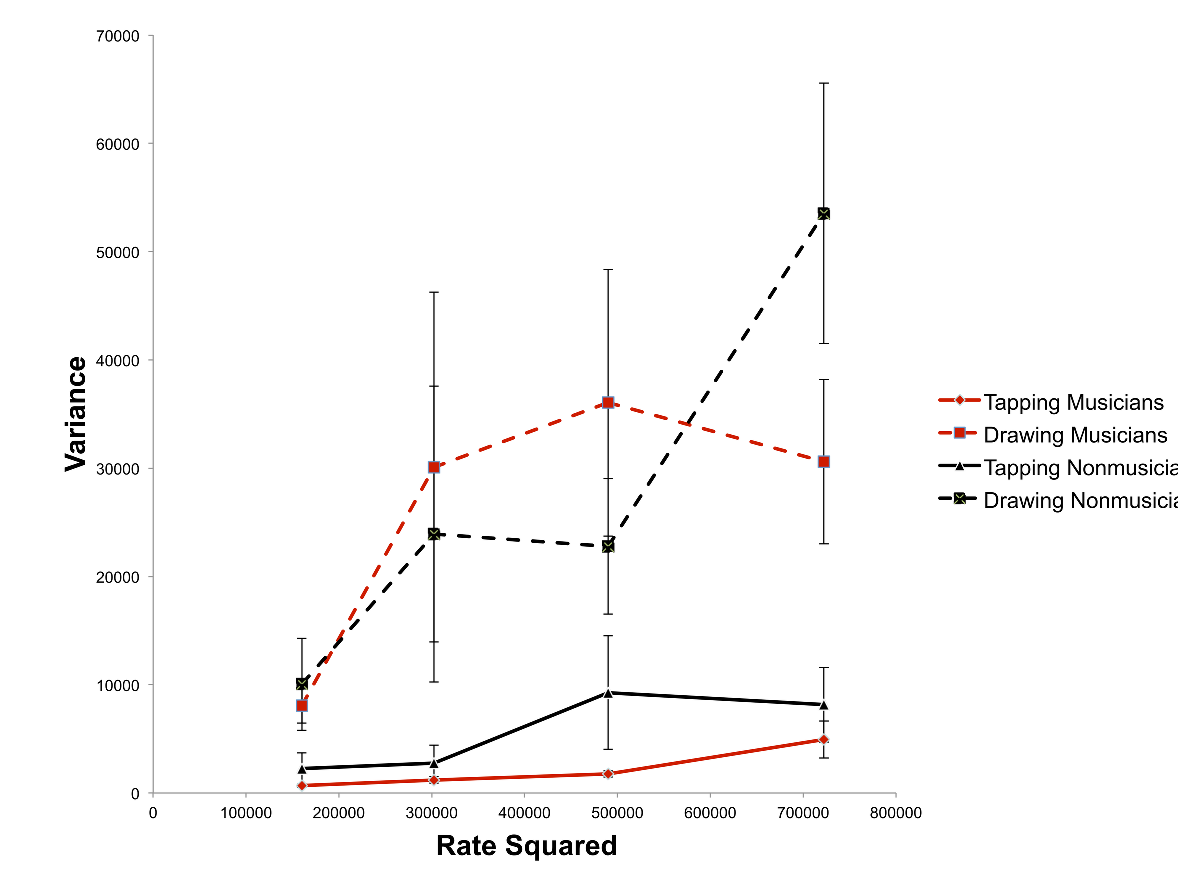


Figure 4. Slope analysis[5]

- Slope:
  - Main effect of task: Drawing has a steeper slope than tapping, $F(1,24) = 12.133$, $p < .05$, *partial* $\eta^2 = .336$
  - No effect of musical training
- Intercept:
  - No effect of task or musical training
- Weber fraction (square root of slope):
  - Main effect of task: $F(1,21) = 41.253$, $p < .001$, *partial* $\eta^2 = .663$
  - No effect of musical training

		Tapping Weber fraction	Drawing Weber fraction	Intercept for tapping	Intercept for Drawing
Musicians	Years of musical experience	-.547, $p = .053$	-.025	.436	.297
	Age began playing	.496, $p = .085$	-.065	-.168	-.502, $p = .067$
Non-musicians	Years of musical experience	-0.029	.387	-.226	-.138

Table 3. Bivariate correlations for slope analysis.

Discussion

- Correlation between years of musical experience (lessons and playing) and the slope of timer variability as a function of rate of unpaced tapping:
  - Trended to significance. More subjects needed.
  - Could indicate that total length of musical training improves the accuracy of an internal pacemaker such that error grows more slowly as a function of interval duration.
- No group differences for circle drawing, marginally significant difference for tapping
  - Musical experience may be aiding tapping but not drawing, suggesting that the timing of these tasks is governed by distinct processes.
- Slope analysis:
  - Correlation between years of musical experience and the Weber fraction for tapping variability is consistent with the analysis of unpaced tapping using the Wing-Kristofferson model.
  - Difference in the pattern of correlations between 2 different measures related to musical experience and tapping and drawing Weber fractions lends support to the theory that event-based and emergent timing are distinct processes.
  - An earlier start to musical training is associated with a smaller rate of increase of duration-dependent variability for tapping only, consistent with other research in our lab investigating a sensitive period for musical training.

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