“Eigentempo”: A large-scale online study investigating factors affecting the spontaneous motor tempo

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Slow Motion
Transformations of Musical Time

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Background and aim

The spontaneous motor tempo (SMT) describes the pace of regular and repeated movements such as walking. The SMT is typically measured with a finger-tapping paradigm, whereby participants tap with their index finger at the pace that feels most natural and comfortable to them. The SMT is important for sensorimotor synchronization to musical rhythms (Drake et al., 2000), it highly correlates with the preferred perceptual tempo, modulating corticospinal excitability (Michaelis et al., 2014). SMT tends to cluster around 500–600 ms (Moelants, 2002) and is influenced by:

- **Age**: Slower at higher age (McAuley et al., 2006).
- **Musical experience**: Musicians tend to prefer a slower SMT (Drake et al., 2000; Scheurich et al., 2018).
- **Arousal**: Faster with increased arousal (Boltz, 1994).
- **Circadian rhythm**: SMT seems to depend on the time of the day (Moussay et al., 2002).

The aim of the study was to investigate the effects of factors affecting the SMT outside of a lab environment, i.e. in an individual’s familiar surroundings, by implementing the finger-tapping paradigm in a web application.

Method

Using a self-developed web application, participants tapped their index finger on a device of their choice for 15 seconds. The task was to “keep the time between each tap as even as possible” at a pace that felt “most comfortable and natural”. If the tapping was too irregular (max. *CV* = 0.1), participants were asked to repeat the tapping task. Additional variables collected included:

- Age
- Musical experience (rating scale)
- Arousal (rating scale)
- Long-term stress inventory (PSS-4 score)
- Weekly work load (rating scale)
- Time of the day (hour of test)

Participants:

- *N* = 3,576
- Age (years): *M* = 27.6, *SD* = 7.61, Range = 42
- Gender: male: 64%, female: 35%, diverse: 1%
- Country of origin: 74 countries (81.2% from China)

Results

Descriptive:

The mean inter-tap interval, as the measure of SMT, was 780 ms (*SD* = 328). Due to a multi-modal data distribution (Fig. 1), a *Gaussian mixture model* (GMM) was applied, which grouped the participants into six clusters (Tab. 1).

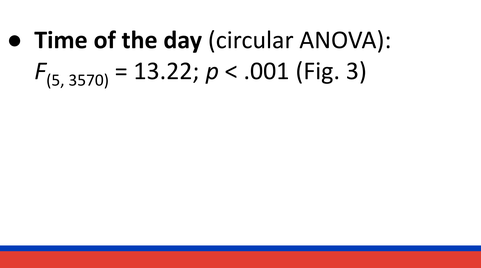

Fig. 1: Distribution of the SMT data. The solid line indicates the mean and the dashed line the median. Each color represents a cluster. The bar width represents 25 ms.

Table. 1: Number, mean, standard deviation and range of the SMT for the six clusters.

Cluster	SMT (ms)		
	N	*M* (*SD*)	*Range limits*
Very Fast	223	265 (74)	123–375
Fast	1184	525 (70)	375–642
Moderately Fast	925	754 (67)	642–875
Moderately Slow	852	996 (77)	875–1164
Slow	283	1314 (106)	1167–1541
Very Slow	109	1757 (166)	1543–2150

Differences between clusters:

One-way *Analysis of variance* (ANOVA) of the factors (see “Method”) showed the following main effects between the clusters:

- **Age**:
  $F_{(5, 3570)} = 8.79$, $p < .001$, $\eta^2 = .01$ (Fig. 2A)
- **Musical experience**:
  $F_{(5, 3570)} = 4.91$, $p < .001$; $\eta^2 = .01$ (Fig. 2B)

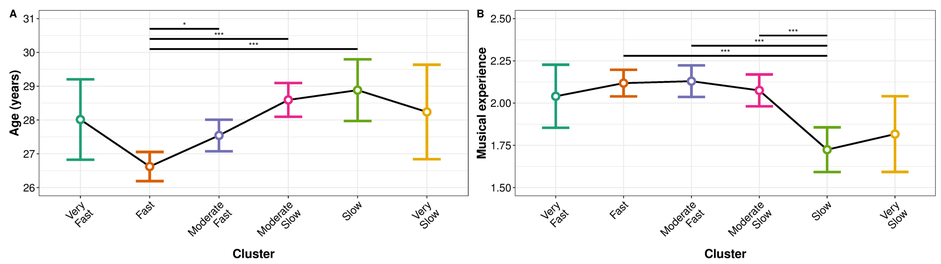

Fig. 2: A) Age distribution of the clusters. B) Musical experience of the clusters. Dots in A) and B) indicate the mean value and error bars the 95% confidence intervals. Horizontal lines and asterisks represent sig. differences.

- **Time of the day** (circular ANOVA):
  $F_{(5, 3570)} = 13.22$; $p < .001$ (Fig. 3)

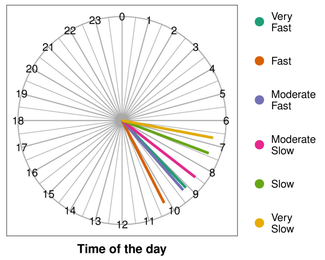

Fig. 3: Average time (hour) of test execution for each cluster.

Results

Regression on normalized SMT across clusters:

SMT data were cluster-wise z-transformed before applying a multiple regression analysis. This approach allowed for the testing of factor differences across all clusters (Fig. 4).

- $F_{(5, 3570)} = 2.55$, $p < .05$; $\eta^2 = .01$
- $R^2 = .004$

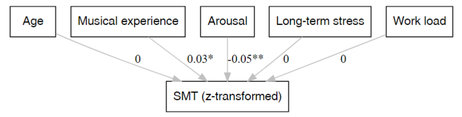

Fig. 4: Multiple regression model. The values represent the coefficients and asterisks indicate sig. influences on the SMT.

Summary and conclusions

- SMT shows a multi-modal distribution.
- The **slowing-with-age** effect was confirmed.
- The level of arousal did not affect clusters, but led to faster SMTs across all clusters. Overall, participants may have taken part in relatively relaxed situations.
- **Musically less experienced** participants preferred the Slow cluster, while across all clusters, higher **musical experience** resulted in slower SMT. Thus, while results depended on musical experience, the direction and underlying cause of the influence warrants further investigations.
- **Time of the day:** The earlier it was during the day, the slower was the SMT.
- There was no influence of long-term stress and perceived work load.

With a large international sample, these results provide new and more detailed insights into the effects of factors that influence the SMT.

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