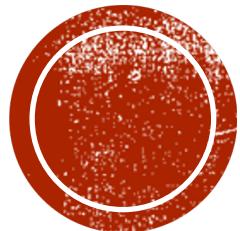


Can Background Music Facilitate Learning?

Preliminary Results on Reading Comprehension



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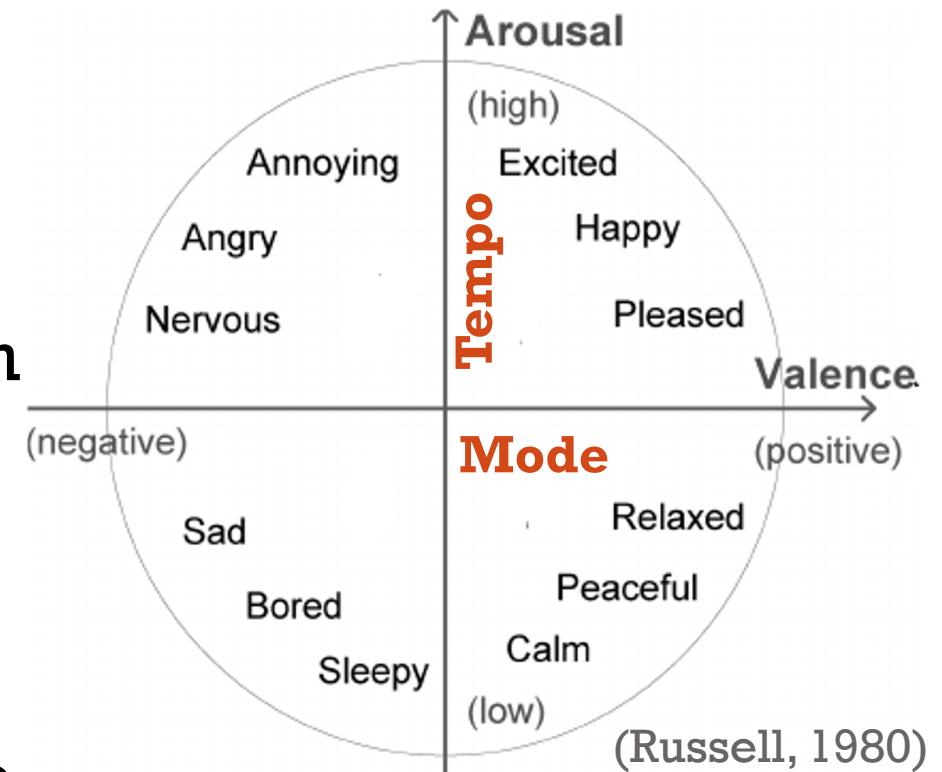
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Background

- Growing attention in LA to the **affective aspects of learning**
- **Music** as an accompaniment to learning activities & a tool for emotion modulation
- **Emotion** affects learning
- **Inconsistent findings** on the effects of music on learning **call for new evidence**
- Most studies were based on **behavioural** measures, could **physiological** measures help?



Objective

- To investigate how **background music** affects **learning performance** and **engagement** based on analytics at both **behavioral** and **physiological** levels.



Methodology

- An **experimental** approach
 - Learning tasks and materials
 - Music /audio
 - Experiment procedure



Experiment Design

Learning Tasks

Reading Materials



5 English
passages



SOURCE: newsela.com

Reading Comprehension

- Science and Mathematics
- Similar readability (~ grade 10)
- Similar length (~136 words)

Performance Assessment

- 4 T/F questions (each passage)
- 2 text-based questions
- 2 inference questions



Time duration of:

- reading
- question answering



Experiment Design

Background Audio

4 Music Pieces

TEMPO fast slow

MODE major minor

↑ Manual selection

Steady tempo/mode,
Consistent emotions

100 pieces

↑ Audio signal processing

Instrumental Music

1K pieces

↑ Random selection

Jamendo Dataset

10K pieces

5 Conditions

1 Environmental Sound

sea wave & seagull

↑ Manual selection

naturesoundsfor.me



Experiment Design

Procedure

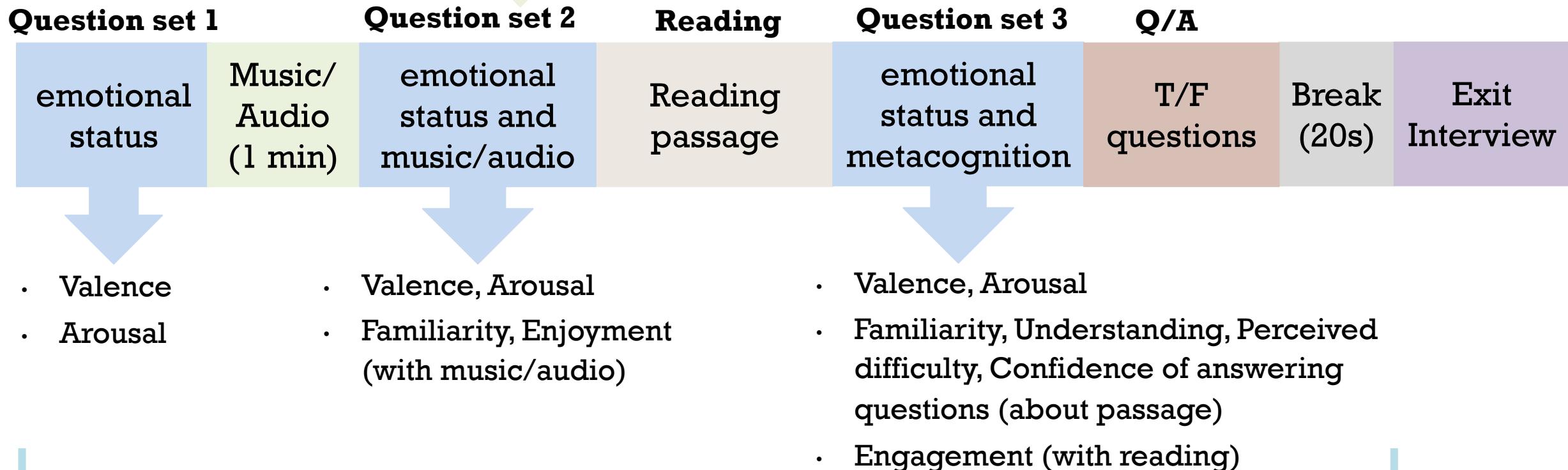


Pre-survey (background)

Practice Block

Formal Experiment

Music/Audio played continuously



repeat 5 times: the order and combinations of audio & passages were counter balanced



Experiment Design

Physiological Data

Empatica E4



- Electrodermal Activity (EDA)
- Blood Volume Pulse (BVP)
- Inter Beat Interval (IBI)
- Heart Rate (HR)
- Skin Temperature (TEMP)



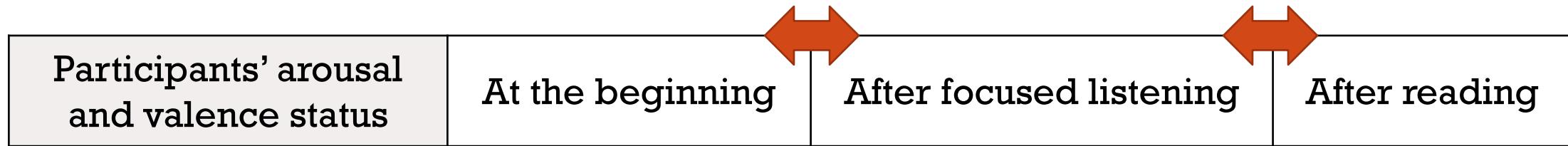
Indicators Extracted from Physiological Data

CATEGORIES	INDICATORS
Descriptive statistics	Mean, standard deviation, median, range
Time series	Means of the values of the 1st (MFD)/ 2nd (MSD) differences of the signals
Spectrum analysis	High frequency (HF), low frequency (LF), LF / HF



Preliminary Results

Effects on Emotion Changes



ONE-WAY ANOVA Comparing 5 audio conditions



N = 33 (19 female)
Graduate students
L2 learners

Table 1: Effects on Emotion Changes

Changes	Emotion	F value	Post hoc Tests
Before and after focused listening	Arousal	13.64***	Fast-minor (1.55) vs. Slow-minor (-0.33)***
	Valence	5.06***	Fast-major (0.79) vs. Slow-minor (-0.27)**
Before and after reading	Arousal	0.98	-
	Valence	2.44	-

***: $p < 0.001$; ** $p < 0.01$; values in parentheses are mean changes in that condition



ONE-WAY ANOVA Comparing 5 audio conditions



Construct	F-value	Post-hoc Test
Engagement in reading	2.70 *	Fast-minor (5.48) Slow-major (5.03) *

- Fast-minor music piece helped the participants engage more in reading than the slow-major piece
- In Literature: fast tempo improves arousal; certain degrees of arousal help learning.



ONE-WAY ANOVA Comparing 5 audio conditions



Construct	F-value	Average values
Accuracy of answering T/F question	0.488	Slow-major (0.82) Environmental (0.75)
Time on reading	0.132	Slow major (168.0 s) Environmental (181.2 s)
Time on answering questions	0.965	Fast-major (36.1 s) Fast-minor (46.4 s)

- No significant difference
- Support that background music/audio doesn't affect learning performance
- Or, were the tasks designed too simple for the participants?



Physiological Signals Processing

- **Normalization:** As physiological signals vary across individuals, the **z-score** normalization was conducted within each individual participant.
- **Alignment:** physiological signals were aligned with the starting and ending time of 1) **focused music/audio listening** and 2) **passage reading with music/audio as background**.
- **Feature Extraction:**

CATEGORIES	INDICATORS
Descriptive statistics	Mean, standard deviation, median, range
Time series	Means of the values of the 1st (MFD)/ 2nd (MSD) differences of the signals
Spectrum analysis	High frequency (HF), low frequency (LF), LF / HF

ONE-WAY ANOVA Comparing 5 audio conditions



Indicator	F-value	Post-hoc tests
EDA_LF/HF during focused listening	2.59 *	Fast-major (1.22) Fast-minor (1.07) *

- No significant difference on physiological indicators during reading
- Support that background music/audio while reading doesn't affect emotion
- Is this because learners' attention was on reading rather than music?



Preliminary Results

ONE-WAY ANOVA
Comparing 5 audio conditions
On Sub-datasets



Effects on Groups of Participants

Table 3: Effects on Groups of Participants

Group	Variable	F value	Post hoc Tests
Listen to background music	Valence before & after reading	3.07*	Slow-minor (0.25) vs. Environment (-0.75) *
Dislike the audio	EDA_MFD during reading	2.62*	Slow-major (0.10) vs. Environment (0.02)*
	EDA_MSD during reading	3.32*	Environment (0.02) vs. Slow-major (0.13)** Fast-major (0.03) vs. Slow-major (0.13)* Fast-minor (0.03) vs. Slow-major (0.13)* Slow-major (0.13) vs. Slow-minor (0.03)*
Familiar with the audio	Arousal before and after reading	3.68**	Fast-minor (-1.08) vs. Slow-major (0.60)* Fast minor (-1.08) vs. slow minor (1.00)*

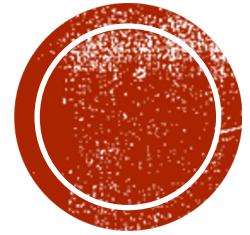
**: $p < 0.01$; *: $p < 0.05$; values in parentheses are mean changes in that condition



Summary and Future Work

- The effect of background music **may vary across individuals/groups of learners.**
- Further analysis will be conducted by **comparing participant groups split with more fine-grained criteria**
- Exploration on relationships among variables using **prediction modelling**
- Towards ultimate goal of optimizing music listening for learning





THANK YOU! Q?A

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