

The effect of timbre proximity on auditory stream formation in polyphonic music: preliminary discussion on behavioral outcomes

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Purpose

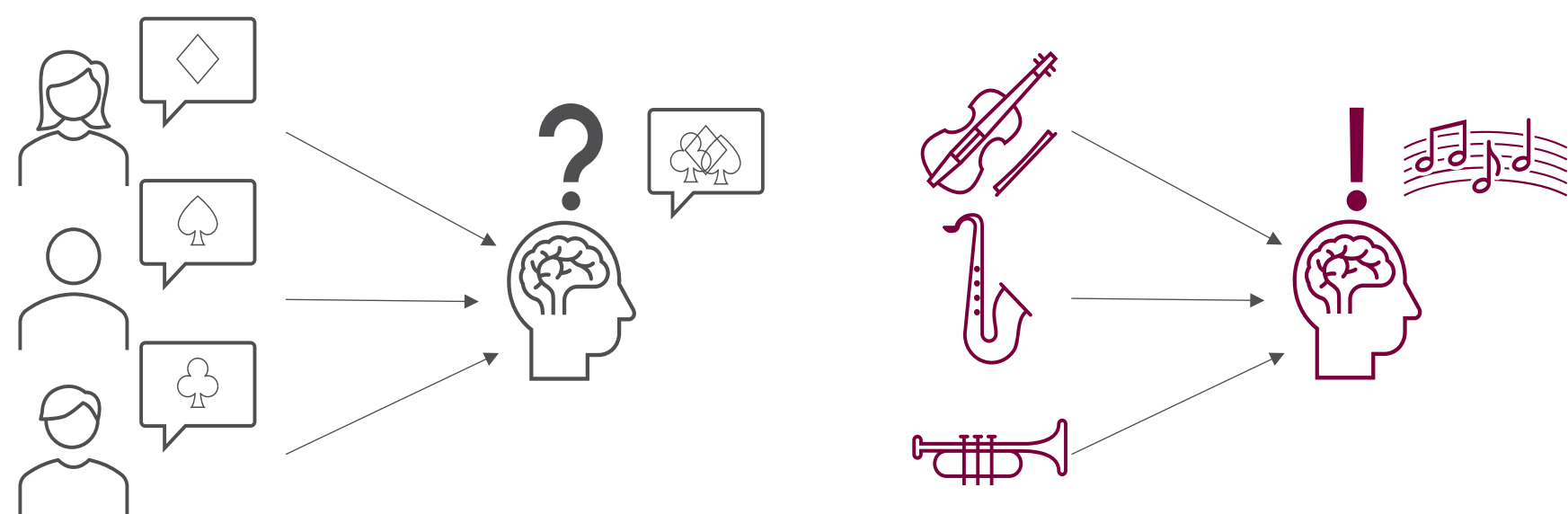
1. Study the effect of timbre on the ability to integrate or segregate sound streams
2. Verify the experimental paradigm for a future EEG study

Background

- Auditory Scene Analysis is a model for auditory perception (Bregman, 1990)
- Incoming sound sources form auditory streams, which then can be either integrated or segregated
 - Stream Segregation: Assignment of incoming sound sources to distinct perceptual objects
 - Stream Integration: Grouping of multiple sound sources into one object
- Whether streams are integrated or segregated depends on both bottom-up (e.g. timbre) and top-down (e.g. attention) information

Objective

- Music can be both integrated and segregated, unlike speech
 - Many speakers at once → Unintelligible
 - Many instruments at once → Music!
- This makes music an ideal medium for studying stream formation, since we can investigate different states of top-down attention
- We can modify the physical features of stimuli (e.g. timbre) without making it sound unnatural
- Thus, we can study the interplay between bottom-up influences (e.g. timbre) and top-down influences (e.g. attention) on the stream formation process



Hypothesis

- H1: Increasing timbre distance will make integration more difficult
- H2: Increasing timbre distance will make segregation less difficult

Research Questions

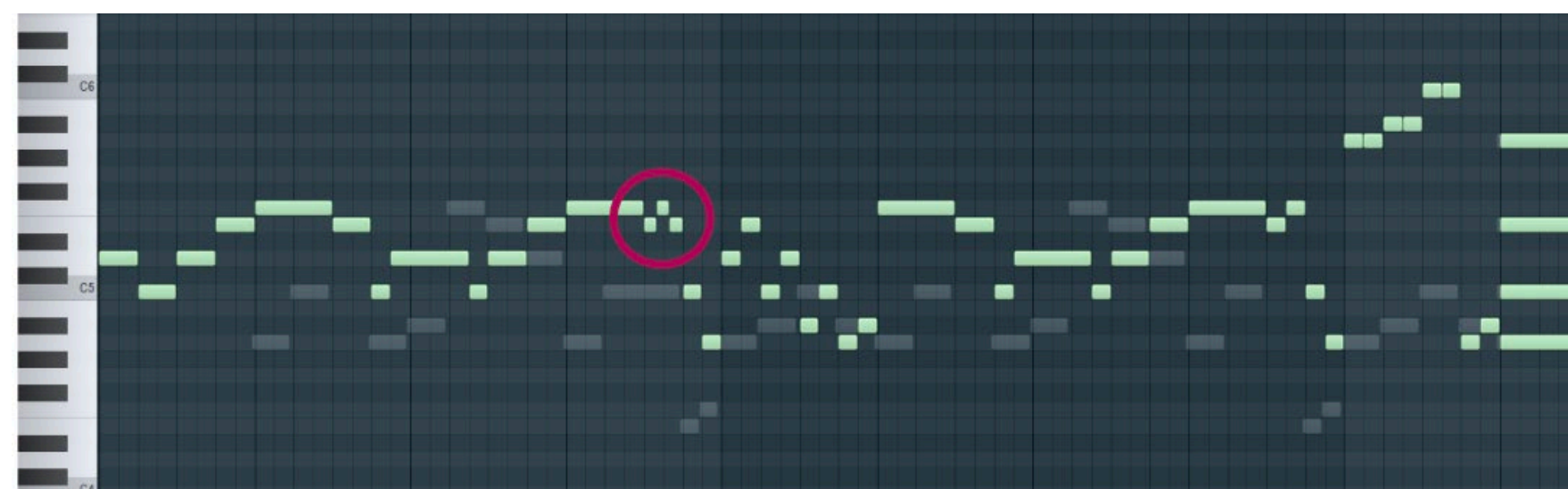
1. How does timbre distance affect integration or segregation of sound streams in music?
2. Does our experimental paradigm accurately measure the effect?

Experiment

- Participants listened to pieces of music with two simultaneous instruments
- Participants were instructed to either attend to both instruments (integration trials) or one instrument (segregation trials)
- Participants detected a target sound from the attended instrument(s)
- Targets were either grace notes or triplets
- Participants responses were timestamped and recorded
- Participants completed 8 practice trials, and only completed experiment if 50% accuracy could be achieved

Stimuli

- Pieces were composed using *FL Studio*, a digital audio workspace
- Using *Serum*, a wavetable synthesizer, instrument timbres were morphed along a continuum of *timbre distances* (TD)
- TD ranged from 0–100, where two instruments had identical timbres at TD = 0 and most distinct at TD = 100
- Pieces were assigned with randomized target positions and tempos



Analysis Methods

- Accuracy for each trial was calculated according to a confusion matrix
- Accuracy = $(TP + TN) / (TP + TN + FP + FN)$

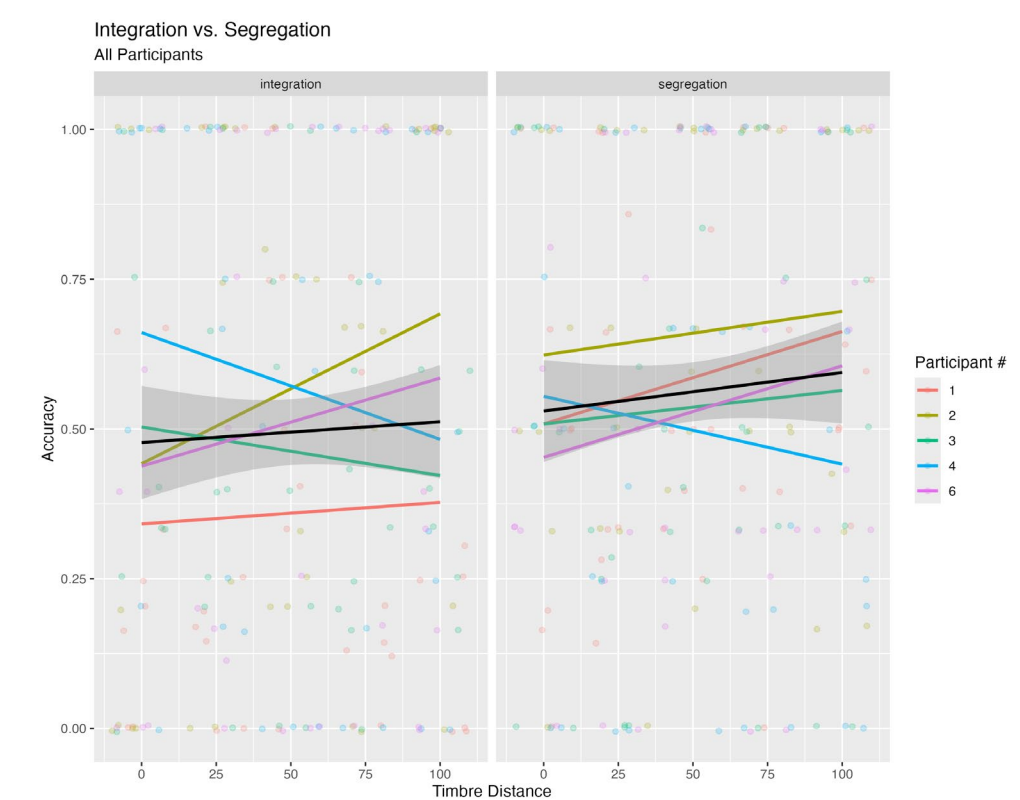
	Response (pressed space bar)	No Response (did not press space bar)
Target Present	True Positive (TP)	False Negative (FN)
Target Absent	False Positive (FP)	True Negative (TN)

- Responses were tagged as "Target Present" when participant input was within 2000ms of target appearance
- Accuracies were averaged across each degree of timbre morphing, and by trial type (integration or segregation)
- Accuracies were also measured based on target type (grace note or triplet) to see if target type affects accuracy

Results

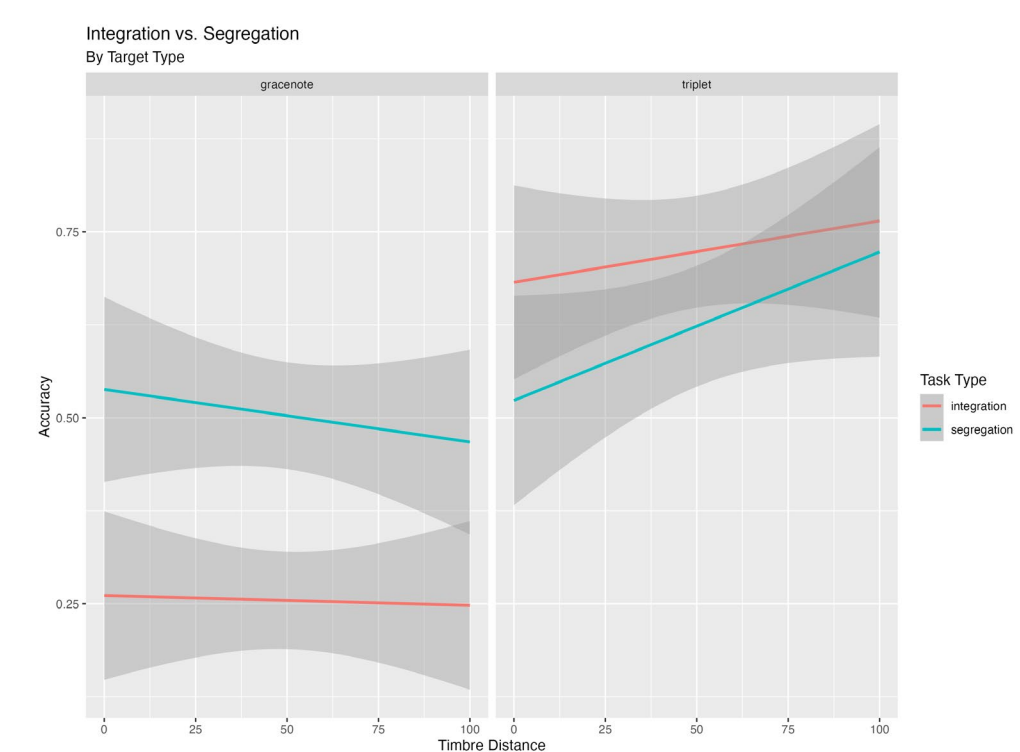
Accuracy vs. Timbre Distance:

- Segregation trials became easier as timbre distance increased
- Integration trials were not affected in difficulty when timbre distance was changed



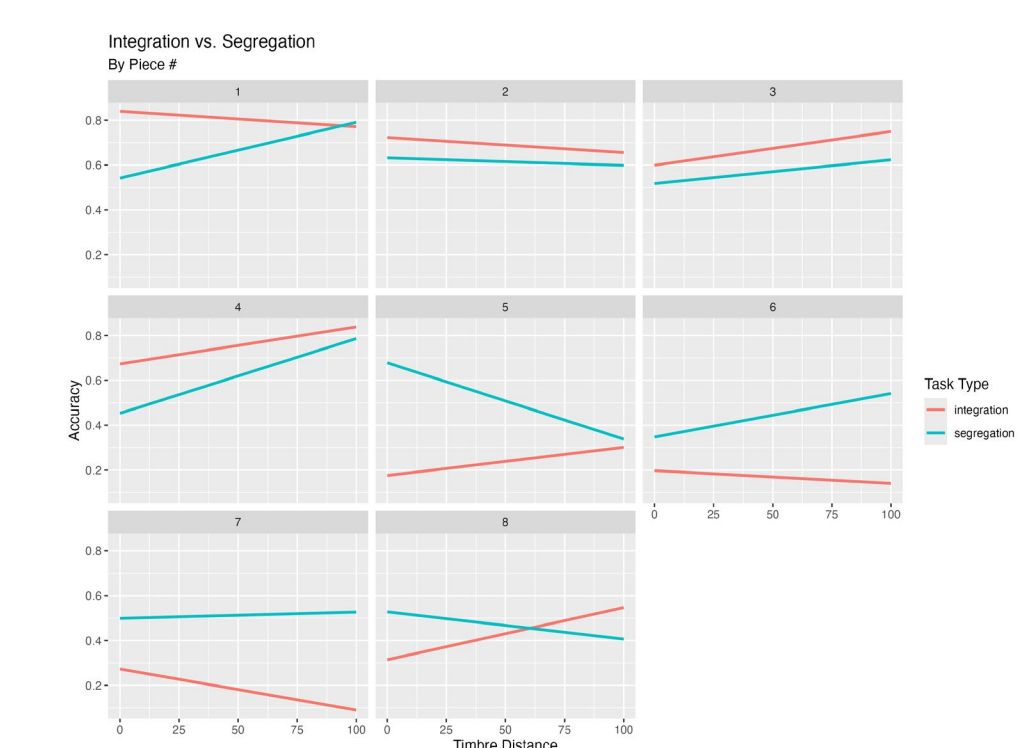
By Target Type:

- Triplet note task seems to have a higher accuracy overall
- Triplet note task followed the general trend of segregation, while grace note task did not



By Piece:

- Most pieces follow the general trend during the segregation task, i.e.) higher TD is associated with higher accuracy
- For pieces #5 and #8, further investigation is needed



Discussion

Current Works

- Current stimuli successfully modulates participant behavior on stream segregation via manipulation of timbre distance
- Timbre distance seems to not affect integration ability strongly
- Task type and piece # appears to effect results, though with low participant count this may not be significant

Future Directions

- Paradigm will be used for EEG study
- Neural mechanisms behind stream formation will be examined
- How does timbre and attention affect stream formation?