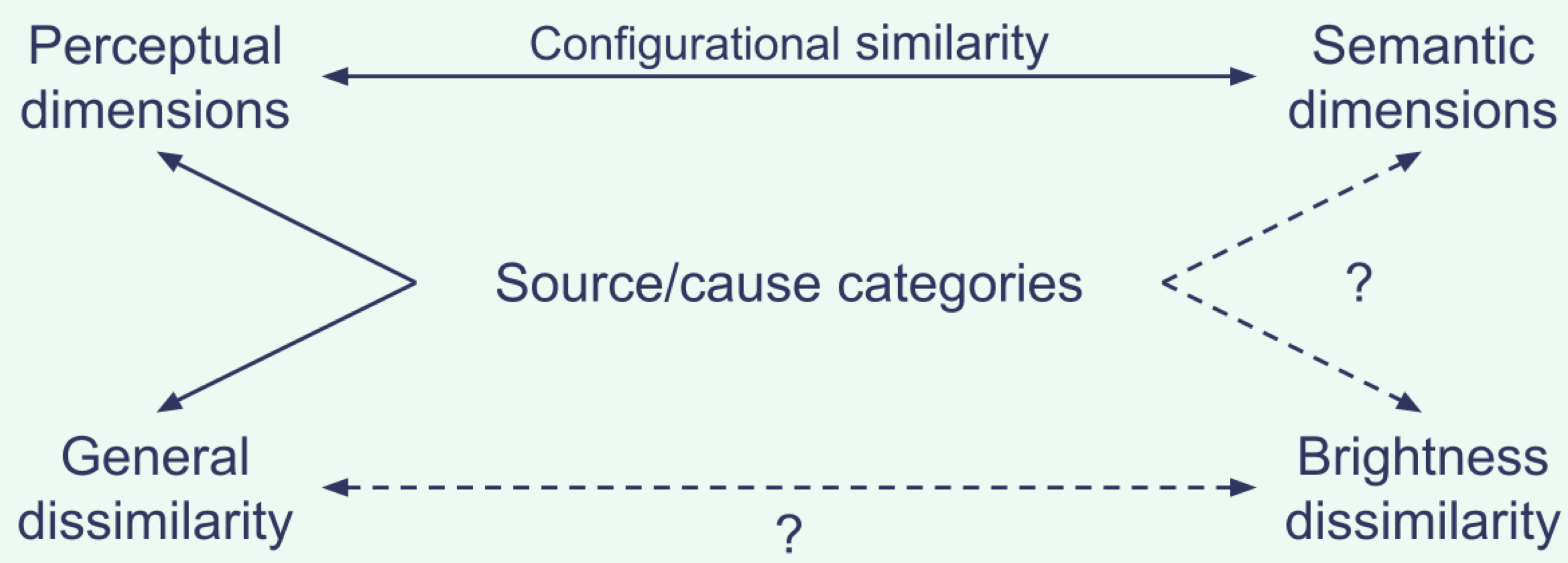
Revisiting timbral brightness perception

Charalampos Saitis[1], Kai Siedenburg[2], Christoph Reuter[3]

[1] Centre for Digital Music, Queen Mary University of London (United Kingdom)
[2] Department of Medical Physics and Acoustics, Carl von Ossietzky University of Oldenburg (Germany)
[3] Musicological Department, University of Vienna (Austria)

c.saitis@qmul.ac.uk



Main results

Brightness dimension in timbre space **not** "purely" spectral.

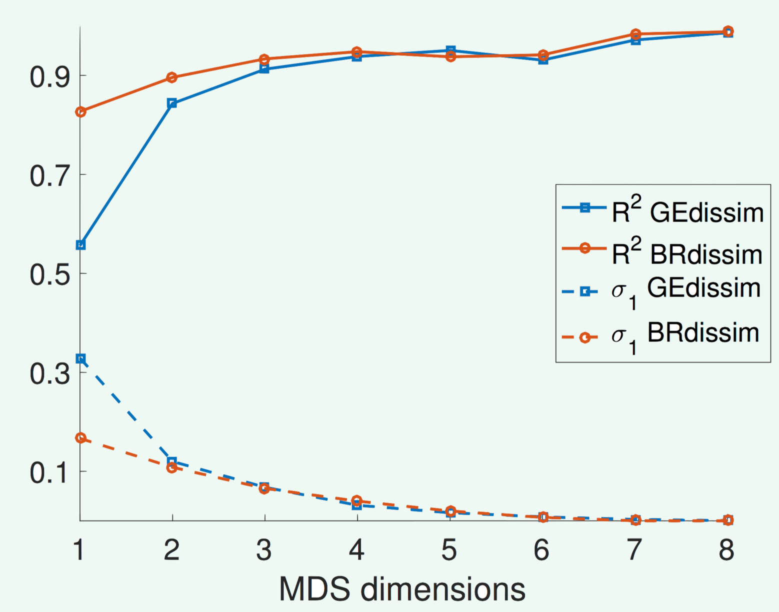
Between **sounds** with very close spectral centroid values but different attack times, those **with faster attacks tend to be perceived as brighter**.

Source/cause categories influence general dissimilarity but **not** brightness dissimilarity.

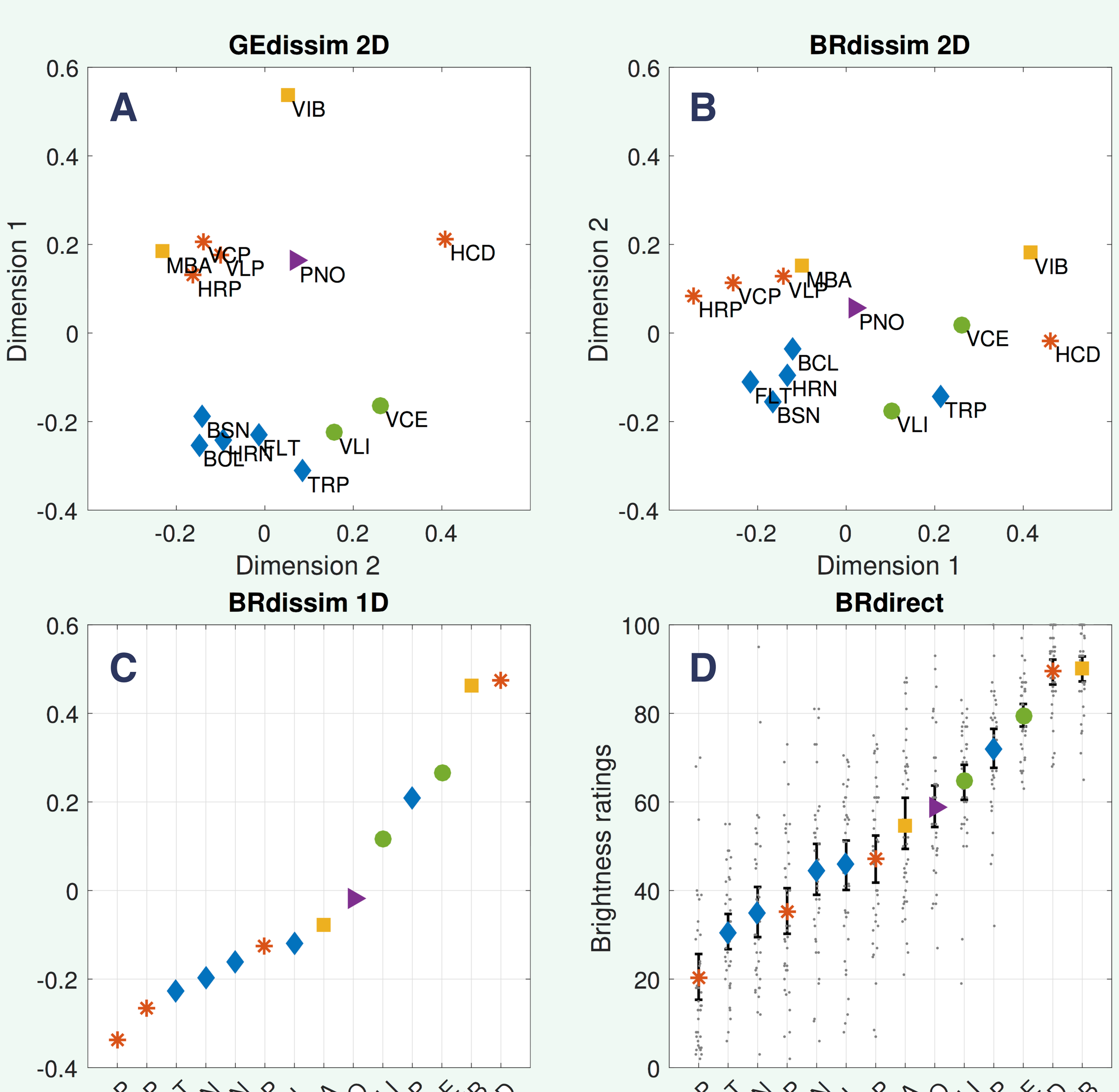
Study 1: Relation to general timbre dissimilarity and source/cause categories

Methods

- **14 instrumental sounds** & 40 musically experienced listeners
- General and brightness dissimilarity ratings & direct multi stimulus brightness ratings
- **Multidimensional scaling analysis (MDS)** & comparisons via **congruence coefficient** (CC), **modified RV coefficient** (RV-mod), and **Procrustes analysis metric** (m^2)
- Modeling of raw dissimilarities by means of **partial least-squares regression (PLSR)** using 12 temporal and 22 spectral audio descriptors (Timbre Toolbox) and 4 categorical descriptors



Results: MDS analysis



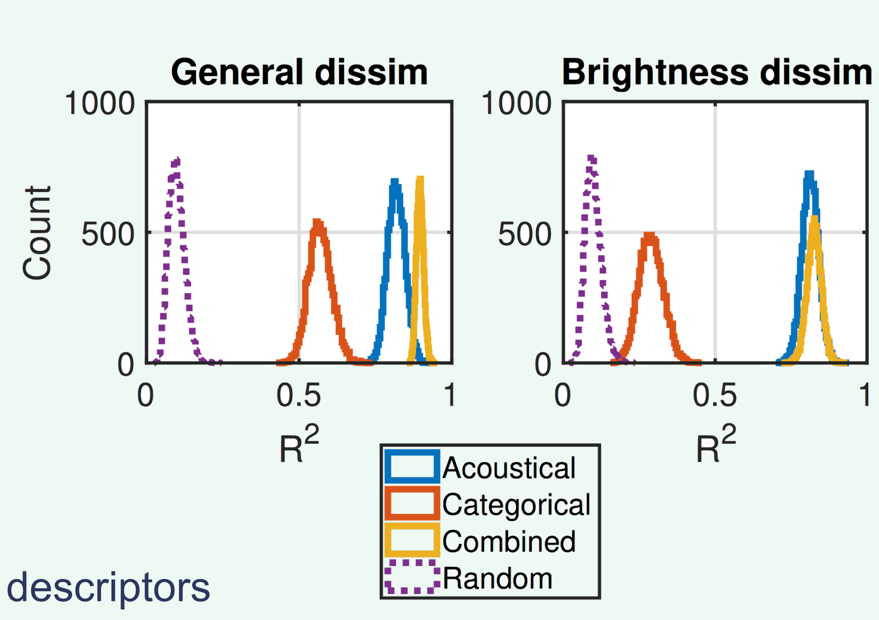
Relation	CC (exp., SD)	r
A - B	**.84 (.86, .04)**	**.74*** **
B2 - A1	**.87 (.87, .06)**	**.87*** **
B1 - A2	.83 (.83, .08)	.83***
B1 - D	.99 (.99, .00)	.98***
A2 - D	.92 (.92, .04)	.77**
C - D	.99 (.99, .00)	.98***
	RV-mod	**m^2**
A - B	**.41****	**.40*** **

** p < .01 *** p < .001

- Brightness dimension in timbre space not "purely" spectral
- Acoustic instrument sounds exhibit an inherent correlation of spectral and temporal features

Results: PLSR modeling

4 types of source/cause categories	
Excitation	continuous, impulsive
	blown, bowed, struck, plucked
Resonator	string, air column, bar
Family	woodwinds, brass, keyboards, strings, percussion



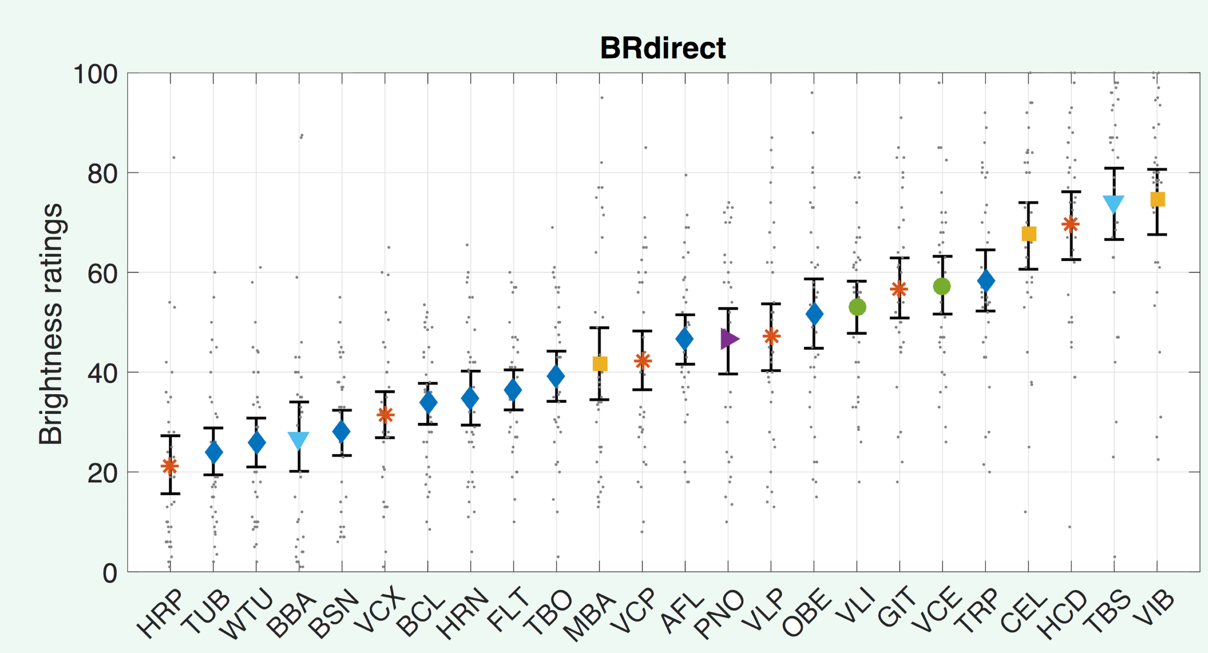
- Bootstrapped R^2 for PLSR models with different sets of descriptors
- Evidence for influence of source-cause categories in general dissimilarity but not in brightness dissimilarity

Study 2: Is faster also brighter? Relation to onset temporal cues

Methods

- **14 + 10 instrumental sounds** & 36 musically experienced listeners
- Direct multi stimulus brightness ratings
- **Linear mixed effects model analysis** with crossed (maximal) random effects design
- **Spectral centroid (SCG)** and **(log) attack time (LAT)** (Timbre Toolbox)

Results



Brightness ~ 1 + SCG*LAT
+ (1 + SCG + LAT | Listener)
+ (1 + SCG + LAT | Stimulus)

Fixed effects	df	F	p
Intercept	1, 85.15	8.90	.003
SCG	1, 82.90	17.58	< .001
LAT	1, 59.09	**6.18**	**.016**
SCG x LAT	1, 57.59	**7.68**	**.008**
R^2 = .65			

- Evidence of influence of LAT on brightness perception—likely not a "pure" effect but rather due to an interaction with SCG
- A similar analysis with synthetic stimuli suggests that fluctuation of SCG during the onset of a sound may play a role in brightness perception

References

Saitis C, Siedenburg K (in preparation) Brightness perception of acoustic instrument sounds: relation to general timbre dissimilarity and source/cause categories.

Siedenburg K, Jones-Mollerup K, McAdams S (2016) Acoustic and categorical dissimilarity of musical timbre: Evidence from asymmetries between acoustic and chimeric sounds. Front Psychol 6:1977

Siedenburg K, Saitis C, McAdams S, Popper AN, Fay RR, editors (2019) Timbre: Acoustics, Perception, and Cognition. Springer, Cham

Peeters G, Giordano BL, Susini P et al (2011) The Timbre Toolbox: Audio descriptors of musical signals. J Acoust Soc Am 130:2902–2916

Marozeau J, de Cheveigné A (2007) The effect of fundamental frequency on the brightness dimension of timbre. J Acoust Soc Am 121:383–387

Zacharakis A, Terrell MJ, Simpson AJ, Pastiadis K, Reiss JD (2017) Rearrangement of timbre space due to background noise: Behavioural evidence and acoustic correlates. Acta Acust united Acust 103:288–298

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