



Figure 3. Comparison of systems' performance with Cronbach's alpha per category.

three dimensions in the GEMS model, which are best explained by axes spanning *calmness—power*, *joyful activation—sadness* and *solemnity—nostalgia*). This finding is supported by other studies in the field [4, 13].

We conclude that it is possible to predict induced musical emotion for some emotional categories, such as *tenderness* and *joyful activation*, but for many others it might not be possible without contextual information. We also show that despite this limitation, there is still room for improvement by developing features that can better approximate human perception of music, which can be pursued in future work on emotion recognition.¹⁰

8. REFERENCES

- [1] A. Aljanaki, D. Bountouridis, J.A. Burgoyne, J. van Balen, F. Wiering, H. Honing, and R. C. Veltkamp: "Designing Games with a Purpose for Data Collection in Music Research. Emotify and Hooked: Two Case Studies", *Proceedings of Games and Learning Alliance Conference*, 2013.
- [2] A. Aljanaki, F. Wiering, and R. C. Veltkamp: "Collecting annotations for induced musical emotion via online game with a purpose Emotify", www.cs.uu.nl/research/techreps/UU-CS-2014-015.html, 2014.
- [3] H.-T. Cheng, Y.-H. Yang, Y.-C. Lin, I.-B. Liao, and H. H. Chen: "Automatic chord recognition for music classification and retrieval", *IEEE International Conference on Multimedia and Expo*, pp. 1505–1508, 2008.
- [4] J. R. J. Fontaine, K. R. Scherer, E. B. Roesch, and P. C. Ellsworth: "The World of Emotions is not Two-Dimensional", *Psychological Science*, Vol. 18, No. 12, pp. 1050–1057, 2007.
- [5] D. Guan, X. Chen, and D. Yang: "Music Emotion Regression Based on Multi-modal Features", *CMMR*, p. 70–77, 2012.
- [6] C. A. Harte, and M. B. Sandler: "Detecting harmonic change in musical audio", *Proceedings of Audio and Music Computing for Multimedia Workshop*, 2006.
- [7] C. Laurier, O. Lartillot, T. Eerola, and P. Toivainen: "Exploring Relationships between Audio Features and Emotion in Music", *Conference of European Society for the Cognitive Sciences of Music*, 2009.
- [8] C. McKay, and I. Fujinaga: "Automatic genre classification using large high-level musical feature sets", *In Int. Conf. on Music Information Retrieval*, pp. 525–530, 2004.
- [9] B. Schuller, J. Dorfner, and G. Rigoll: "Determination of Nonprototypical Valence and Arousal in Popular Music: Features and Performances", *EURASIP Journal on Audio, Speech, and Music Processing, Special Issue on Scalable Audio-Content Analysis* pp. 735–854, 2010.
- [10] B. Sollberge, R. Rebe, and D. Eckstein: "Musical Chords as Affective Priming Context in a Word-Evaluation Task", *Music Perception: An Interdisciplinary Journal*, Vol. 20, No. 3, pp. 263–282, 2003.
- [11] K. Torres-Eliard, C. Labbe, and D. Grandjean: "Towards a dynamic approach to the study of emotions expressed by music", *Proceedings of the 4th International ICST Conference on Intelligent Technologies for Interactive Entertainment*, pp. 252–259, 2011.
- [12] J. K. Vuoskoski, and T. Eerola: "Domain-specific or not? The applicability of different emotion models in the assessment of music-induced emotions", *Proceedings of the 10th International Conference on Music Perception and Cognition*, pp. 196–199, 2010.
- [13] L. Wedin: "A Multidimensional Study of Perceptual-Emotional Qualities in Music", *Scandinavian Journal of Psychology*, Vol. 13, pp. 241–257, 1972.
- [14] F. Weninger, F. Eyben, B. W. Schuller, M. Mortillaro, and K. R. Scherer: "On the Acoustics of Emotion in Audio: What Speech, Music, and Sound have in Common", *Front Psychol*, Vol. 4, p. 292, 2013.
- [15] Y.-H. Yang, Y.-C. Lin, Y.-F. Su, and H. H. Chen: "A Regression Approach to Music Emotion Recognition", *IEEE Transactions on Audio, Speech, and Language Processing*, Vol. 16, No. 2, pp. 448–457, 2008.
- [16] Y.-H. Yang, and H. H. Chen: "Machine Recognition of Music Emotion: A Review", *ACM Trans. Intell. Syst. Technol.*, Vol. 3, No. 3, pp. 1–30, 2012.
- [17] M. Zentner, D. Grandjean, and K. R. Scherer: "Emotions evoked by the sound of music: characterization, classification, and measurement", *Emotion*, Vol. 8, No. 4, pp. 494–521, 2008.

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