

2 Related work

This section gives a brief overview of the topic of evaluation in NIME-research by looking at two relevant evaluation frameworks in the field and often assessed evaluation criteria. After that we take a glimpse at the related field of general musical instrument evaluation. The section concludes with a synthesis of this outlook and its implications for our work.

2.1 Evaluation in the domain of New Interfaces for Musical Expression

Only a few years ago Stowell, Plumbley and Bryan-Kinns (2008) noted that there is very little research about evaluation of NIME; but lately, the evaluation of NIME became a topic of major interest (Barbosa et al., 2015). In their review of the NIME-conference proceedings between 2012 and 2014 that applied the term evaluation, Barbosa et al. looked at the considered targets that are often evaluated (DMI, Input, Mapping, Output, Feedback or Performance), stakeholders (performer, audience and designer), goals (e.g. comparison of instruments), evaluation criteria (e.g. controllability), the used research methods (e.g. interviews) and the duration of the evaluative assessments. The authors conclude that there appears to be a lack of general consensus about evaluation in NIME. This matter may be reflected by the notable amount of studies that label themselves with “evaluation”, but omitted to report used criteria, methods or sometimes even goals of the conducted evaluations (Barbosa et al., 2015). This is mentioned to prevent the assessment of validity and replicability in research (Greenberg & Buxton, 2008).

Regarding the term evaluation, O’Modhrain (2011) claimed a broadening of the scope of evaluation. Since the four proposed stakeholder groups in her framework - audience, performer, designer and manufacturer - apply a different understanding of evaluation, each of them should be accounted regarding their special interests. For example, while a manufacturer may be more interested in market surveys and sales, the performer demands an in-depth evaluation of the instrument itself. Based on this and other works, Morreale et al. (2014) presented a user-centered experience framework, which distinguishes between goals (purposes of the interface; e.g. user story) and specifications (interaction requirements derived from the goals).

2.2 Evaluation criteria in NIME

From the few studies that indicated evaluation criteria, the observation of the word cloud analysis (larger words represent more often assessed criteria) by Barbosas et al. (2015) suggests that expressiveness, control, learnability, playability, intuitiveness and fun are the core constructs of interest in NIME-evaluation of the performer’s perspective.

Subsequently, we briefly and not conclusively discuss the central concepts on which NIMES were previously evaluated by looking mostly at the performer's perspective.

Juslin (2003) conceptualized the construct of performer expression in music as a multi-dimensional construct with five facets (GERMS Model). (1) Generative rules apply to the rule-based transformation of scores into music. (2) Emotional expression refers to the ability of communicating emotions through a corresponding musical play. (3) Random variability describes the aspect of performing which is not completely controlled by the musician and makes every performance unique. (4) Motion principles can be intentional for creating specific patterns (e.g. *ritardando*) or non-intentional by referring to physiological limitations of the body and (5) stylistic unexpectedness holds for the created tension by violating and resolving musical expectations. Poepel (2005) operationalized chosen aspects of the GERMS Model for comparing the expressivity of three string instruments (traditional and electric violas with different interface-mapping-syntheses). Jordà and Mealla (2014) assessed expressiveness for the evaluation of performances with different DMIs from the audience's perspective. Kontogeorgakopoulos and Kouroupetroglou (2011) compared the performer's expressivity in two musical tasks with and without haptic feedback using the Falcon haptic device (a haptic control interface). Erkut, Jylhä and Discioglu (2011) presented a model for the design and evaluation of musical interfaces including expression as one dimension of interest among others.

Orio and Wanderley (2002) were specifically interested in adapting usability testing to a musical context and highlighted several concepts suitable for musical tasks (e.g. pitch control or rhythm control). They suggested dividing control into feature controllability (manipulation of sound parameters) and timing controllability (how precisely a performer can play along a given tempo) for the assessment of musical tasks. Johnston, Candy and Edmonds (2008) reflected control from a musician-centered perspective by introducing three different modes of interaction that musicians can occupy. In instrumental mode, musicians aim to control the behavior of the instrument. An ornamental mode emerges when the musician is not intentionally aware of the exact outcome, but rather is positively surprised by the instrument itself. The conversational mode refers to a balance between the instrumental and the ornamental mode. In an evaluation study of the 'Viblotar' (a monochord-type DMI designed for experimental investigations), Marshall and Wanderley (2011) measured the subjectively perceived controllability and ease of use with and without haptic feedback. The subjectively perceived accuracy in sound modification was also investigated for the Falcon haptic device (Kontogeorgakopoulos & Kouroupetroglou, 2011). Birnbaum, Fiebrink, Malloch and Wanderley (2005) looked at musical control divided in three levels (timbral level, note level, and control over a musical process) in a proposed dimension space for DMIs which allows to categorize DMIs.

With relation to control the concept of learnability is extensively discussed: According to Jordà (2004) the ultimate goal for a designer should be to design instruments that are both appealing to the expert and the beginner. Jordà exemplifies this issue by outlining the learning curves of different traditional musical instruments. Whereas the kazoo (a membranophon which modifies the singing voice) can be learned fast and easily, it does not offer lifelong mastery. A violin on the other hand does, but is very hard to learn during the early years. An optimal learning curve is provided by the piano. Even a beginner could soon play beautiful melodies and still develop his musicianship over a lifetime. This notion is supported by O'Modhrain's (2011) remark that a challenging DMI would help to develop virtuosity. Also Wallis, Ingalls, Campana, and Vuong (2013) theoretically discuss which qualities of musical instruments contribute to long-term engagement by looking at self-determination theory of motivation (Ryan & Deci, 2000) and discussing the motives of mastery, autonomy and purpose. Also in that context, an optimal learning curve (Marshall and Wanderley, 2011) or adequate intuitiveness (Overholt, 2009) are expected to be related to engagement. By looking at the DMI categorization of Miranda and Wanderley (2006) where DMIs are divided into instrument-like controllers, extended instruments, instrument-inspired controllers and alternative controllers, Young and Murphy (2015) explained that in alternative controllers familiarity is actively avoided. Thus, intuitiveness may not be a generally applicable facet of interest. Furthermore, enjoyment, entertainment, fun or pleasantness are often assessed concepts with regard to assessing UX in a musical context (Kontogeorgakopoulos & Kouroupetroglou, 2011; Marshall & Wanderley, 2011). Finally, DMIs were also assessed for their explorability, degrees of freedom or their operational freedom (Birnbaum, et al., 2005), range of expression (Overholt, 2009) or expression per se (Erkut, Jylhä, & Discioglou, 2011).

This short glimpse only reflects the major concepts of interest that were previously investigated in NIME research. Because our approach is based on various instruments we likewise wanted to consider possible learnings from evaluation research on traditional musical instruments. Because of the predominant work on the violin in this area, a brief overview over the related work in that area is presented.

2.3 Evaluation of traditional musical instruments - The example of the violin

Within the general field of musical instrument evaluation investigations on traditional musical instruments, sensory perception, preference judgments, and their correlation to objective, physical measures form the dominant research paradigm (Fritz & Dubois, 2015). Fritz and Dubois (2015) reviewed the growing research body in this domain by discussing studies in the field of musical acoustics, which investigates the musical quality of instruments. Methodically, these studies focus on the experimental method of listening and playing tests where the double-blind format has emerged as the gold standard.

Moreover, the general aim of these works is to scientifically define a ‘good’ or a ‘bad’ instrument. For example, a controversially discussed series of studies (Claudia Fritz et al., 2014; Claudia Fritz, Curtin, Poitevineau, Morrel-Samuels, & Tao, 2012; Wollman, Fritz, & Poitevineau, 2014) found that new violins were preferred over old Italians. Fritz et al., (2014) concluded that monetary value and historical importance might be the cause for a biased impression of violins. According to Fritz et al., (2014), subjective taste and playing qualities appear to be more important aspects that account for violin preference. The authors therefore suggested that future research should investigate how musicians subjectively evaluate musical instruments and which playing qualities of the instrument influence their evaluation. It is also mentioned that higher-level perceptual processes are involved when musicians choose instruments (e.g. in a music store).

In conclusion, in NIME-research a number of potentially important quality criteria have been discussed for their assessment of different stakeholder perspectives. However, it remains unclear which of the quality criteria in NIME-research truly contribute to or are more important than others for the subjectively perceived quality of a musical instrument from the perspective of the musician. Furthermore, the relations among the criteria and their individual relation to the higher-level construct of the perceived musical instrument quality remain unclear in both NIME-research and traditional musical instrument evaluation.

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