

Moving Together, Feeling Connected:

A Multimodal Exploration of Movement Entrainment and Social Experience at Live Concerts

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Abstract

Live concerts are exciting social events and attendees are often motivated not only by the music itself, but also by experiencing social connection. There is evidence that this sense of connection is a result of joint movement, which is an inherent part of the concert experience in many musical genres. However, this relationship has to date never been investigated in an ecologically valid concert setting. To address this gap, this thesis presents studies of three datasets investigating movement entrainment, social concert experience, and the relationship of the two in real world concert contexts. The role of the concert format, specifically standing vs. sitting, is also examined in relation to both movement entrainment as well as general and social concert experience. The first study investigated if audience movement entrainment – defined as the extent to which people move to the beat of the music – can be measured in an ecologically valid rock concert during which 42 participants wore sensors on the torso and arm (Concert Dataset 1). Results showed significant movement entrainment relative to control beat frequencies, and average movement entrainment was positively linked to self-reported desire to move and dance. The second study extended this work by examining factors influencing movement entrainment of 69 participants at two big band concerts (Concert Dataset 2). It added an experimental condition to naturally introduce variability into movement entrainment: One concert was seated, whereas the other concert was unseated. Hierarchical linear models revealed that movement entrainment was significantly predicted by location of measurement (arm vs. torso), metrical level (standard vs. half-, and double-time), musical factors (the different pieces), concert format (standing vs. sitting), and the personal characteristic of urge to dance. Concerning general concert experience, there was no effect of the concert format on overall concert evaluation or affective activation, but standing had a significant negative effect on valence. A structural equation model indicated that standing had a significant positive effect on participants' attention to, depth of processing of, and solidarity with other audience members. Further, familiarity with other audience members, general active engagement with music, and positive activation after the concert were positively linked to solidarity. Since the positive correlation between movement entrainment and solidarity showed a non-significant trend – despite the expectation that the solidarity would best reflect the positive effects of joint movement – a follow-up study at a standing-only indie-

pop concert assumed more movement entrainment and employed revised measures to better capture pro-group outcomes of joint movement (Concert Dataset 3). Responses from 39 participants indicated that audience movement entrainment was positively and significantly correlated with social connection in relation to both the other audience members and the musicians, and perceived similarity and closeness to other audience members. Moreover, a multivariate hierarchical linear model revealed that social connection towards the band was higher compared to the audience, and that positive affect and familiarity with the audience, in addition to movement entrainment, were positively and significantly associated with the intensity of social connection. This thesis makes a significant contribution to the field of concert research by demonstrating, for the first time in ecologically valid concert settings, that movement entrainment is a measurable and meaningful phenomenon that, like standing, is related to social experience. This underscores that concerts are not only performances but embodied social events, in which the audience, the music, the performers, and the context co-construct shared experiences.

Zusammenfassung

Live-Konzerte sind nicht nur musikalische, sondern vor allem soziale Ereignisse. Besucher*innen erleben häufig ein starkes Gefühl sozialer Verbundenheit und es gibt Hinweise darauf, dass dieses Gefühl der Verbundenheit das Ergebnis gemeinsamer Bewegung ist, die in vielen Musikgenres einen integralen Bestandteil des Konzerterlebnisses darstellt. Bisher wurde diese Beziehung jedoch noch nie in einem ökologisch validen Konzertkontext untersucht. Um diese Lücke zu schließen, präsentiert diese Dissertation Studien zu drei Datensätzen, die Bewegungs-Entrainment, das soziale Konzerterleben und deren Zusammenhang in realen Konzertkontexten untersuchen. Dabei wird auch die Rolle des Konzertformats – unbestuhlt im Vergleich zu bestuhlt – in Bezug auf sowohl Bewegungs-Entrainment als auch das allgemeine und soziale Konzerterleben analysiert. Die erste Studie untersuchte, ob das Bewegungs-Entrainment des Publikums – definiert als das Ausmaß, in dem sich Teilnehmende zum Beat der Musik bewegen – in einem ökologisch validen Rockkonzert gemessen werden kann. Dafür trugen 42 Personen Sensoren am Oberkörper und Arm (Datensatz 1). Die Ergebnisse zeigten ein signifikantes Bewegungs-Entrainment zur im Konzert gespielten Musik im Vergleich zu Kontroll-Beat-Frequenzen. Zudem war das durchschnittliche Bewegungs-Entrainment positiv mit dem selbstberichteten Wunsch sich zu bewegen und zu tanzen verknüpft. Darauf aufbauend untersuchte die zweite Studie Einflussfaktoren auf das Bewegungs-Entrainment von 69 Teilnehmenden bei zwei Big Band-Konzerten (Datensatz 2). Eine experimentelle Bedingung wurde hinzugefügt, um natürlich Variabilität im Bewegungs-Entrainment zu erzeugen: Ein Konzert war bestuhlt, das andere unbestuhlt. Hierarchische lineare Modelle zeigten, dass das gemessene Bewegungs-Entrainment vom Ort der Messung (Arm vs. Oberkörper), metrischem Level (Standard- vs. Half-Time- bzw. Double-Time-Level), musikalischen Faktoren (den verschiedenen Stücken), dem Konzertformat (Stehen vs. Sitzen) und der persönlichen Eigenschaft „Urge to Dance“ signifikant vorhergesagt wird. In Bezug auf das allgemeine Konzerterleben zeigte das Konzertformat keinen Effekt auf die Gesamtbewertung des Konzerts oder die affektive Aktivierung, jedoch hatte Stehen einen signifikanten negativen Effekt auf die Valenz. Ein Strukturgleichungsmodell ergab zudem, dass Stehen einen signifikanten positiven Einfluss auf die Aufmerksamkeit der Teilnehmenden für, die Tiefe der Verarbeitung von und die Solidarität mit

anderen Personen im Publikum hatte. Darüber hinaus waren Vertrautheit mit anderen Personen im Publikum, genereller aktiver Umgang mit Musik und positive Aktivierung nach dem Konzert positiv mit Solidarität verknüpft. Da die positive Korrelation zwischen Bewegungs-Entrainment und Solidarität nur einen nicht-signifikanten Trend zeigte – entgegen der Erwartung, dass Solidarität die positiven Effekte gemeinsamer Bewegung am besten widerspiegelt – wurde bei einem unbestuhlten Indie-Pop-Konzert eine Folgestudie durchgeführt. Bei diesem Konzert wurde mehr Bewegungs-Entrainment angenommen und es wurden überarbeitete Messinstrumente eingesetzt, um Effekte auf das positive gruppenbezogene Denken gemeinsamer Bewegung besser zu erfassen (Datensatz 3). Daten von 39 Teilnehmenden zeigten, dass das Bewegungs-Entrainment des Publikums positiv und signifikant mit sozialer Verbundenheit mit sowohl den Band-Mitgliedern als auch anderen Personen im Publikum sowie wahrgenommener Ähnlichkeit und Nähe zu anderen Personen im Publikum korreliert. Ein multivariates hierarchisches lineares Modell ergab zudem, dass die soziale Verbundenheit zur Band höher war als zum Publikum und dass positiver Affekt sowie Vertrautheit mit dem Publikum zusätzlich zu Bewegungs-Entrainment die Intensität der sozialen Verbundenheit signifikant positiv vorhersagen. Diese Dissertation leistet einen bedeutenden Beitrag zur Konzertforschung, indem sie erstmals in ökologisch validen Konzerten nachweist, dass Bewegungs-Entrainment ein messbares und bedeutsames Phänomen ist, das – ähnlich wie das Stehen – mit dem sozialen Erleben verknüpft ist. Dies betont, dass Konzerte nicht nur Musikdarbietungen, sondern verkörperte soziale Ereignisse sind, in denen das Publikum, die Musik, Performer*innen und der Kontext gemeinsames Erleben formen.

Contents

List of Tables ix
List of Figures xi
List of Abbreviations xiii
Acknowledgements xv
1 Introduction 1
2 Background 5
2.1 Collective Responses in Concert Audiences 5
2.2 Collective Movement Entrainment Reactions at Concerts 7
2.2.1 Foundations of Movement Entrainment 8
2.2.2 Measuring Movement Entrainment at Concerts 10
2.2.3 Variables Influencing Movement Entrainment 13
2.3 Collective Social Experience at Concerts 15
2.3.1 Theoretical Perspectives on Social Experience at Concerts 15
2.3.2 Measuring Social Experience of a Concert 22
2.3.3 Variables Influencing Social Experience at Concerts 25
2.4 Relationship Between Joint Movement Entrainment and Pro-Group Thinking . . 29
2.4.1 Theoretical and Empirical Foundations 30
2.4.2 The Need for Further Research in the Context of Concerts 32
3 Aims and Objectives 35
4 Exploring Movement Entrainment in Ecologically Valid Concert Settings 37
4.1 Measuring Movement Entrainment 37
4.1.1 Aims 37
4.1.2 Methods 38
4.1.3 Results 45
4.1.4 Discussion 46
4.2 Contributing Factors to Movement Entrainment 48
4.2.1 Aims 48
4.2.2 Methods 49
4.2.3 Results 54
4.2.4 Discussion 60

5 Exploring General and Social Audience Experience in Ecologically Valid Concert Settings . . . 65
5.1 Effects of Standing vs. Sitting on the Audience's Social Experience of the Concert, Their Evaluation of the Concert, and Affective State . . . 65
5.1.1 Aims . . . 65
5.1.2 Methods . . . 66
5.1.3 Results . . . 69
5.1.4 Discussion . . . 73
5.2 Positive Relationships Between Audience Movement Entrainment and Pro-Group Thinking . . . 79
5.2.1 Aims . . . 79
5.2.2 Methods . . . 80
5.2.3 Results . . . 85
5.2.4 Discussion . . . 93
6 General Discussion . . . 99
6.1 Main Findings . . . 99
6.2 Discussion . . . 102
6.3 Limitations . . . 104
6.4 Outlook . . . 106
6.5 Final Conclusions . . . 107
Bibliography . . . 109
A Supplementary Material for Concert Dataset 1 . . . 129
B Questionnaires for Concert Dataset 1 . . . 133
B.1 Pre-Concert Questionnaire . . . 134
B.2 Post-Concert Questionnaire . . . 141
C Supplementary Material for Concert Dataset 2 . . . 147
D Questionnaires for Concert Dataset 2 . . . 165
D.1 Pre-Concert Questionnaire . . . 166
D.2 Post-Concert Questionnaire . . . 175
D.2.1 Sitting Condition . . . 175
D.2.2 Standing Condition . . . 182
E Supplementary Material for Concert Dataset 3 . . . 189
F Questionnaires for Concert Dataset 3 . . . 197
F.1 Pre-Concert Questionnaire . . . 198
F.2 Post-Concert Questionnaire . . . 202

List of Tables

4.1 Set list and BPM values of the pieces of Concert Dataset 1 39
4.2 Set list and BPM values of the pieces of Concert Dataset 2 52
4.3 Hierarchical linear model predicting Movement Entrainment 55

5.1 Results of the linear models examining the effect of the concert condition Standing (vs. Sitting) on Social Experience of the Concert 69
5.2 Comparison of fit indices across models estimated with WLSMV and MLR . . . 70
5.3 Results of the linear models examining the effect of the concert condition Standing (vs. Sitting) on the evaluation of the concert and affective state 73
5.4 Set list and BPM values of the pieces of Concert Dataset 3 81
5.5 Multivariate hierarchical linear model predicting Social Connection 88

C.1 M1 (HLM Concert Dataset 2) 149
C.2 M2 (HLM Concert Dataset 2) 149
C.3 M3 (HLM Concert Dataset 2) 150
C.4 M4 (HLM Concert Dataset 2) 150
C.5 M4a (HLM Concert Dataset 2) 150
C.6 M5 (HLM Concert Dataset 2) 151
C.7 M6 (HLM Concert Dataset 2) 152
C.8 M7 (HLM Concert Dataset 2) 153
C.9 M8 (HLM Concert Dataset 2) 154
C.10 M9 (HLM Concert Dataset 2) 155
C.11 M10 (HLM Concert Dataset 2) 156
C.12 M11 (HLM Concert Dataset 2) 157
C.13 M12 (HLM Concert Dataset 2) 158
C.14 M13 (HLM Concert Dataset 2) 159
C.15 Structural regression paths predicting latent constructs of the SECS 160

E.1 M1 (Multivariate HLM Concert Dataset 3) 192
E.2 M2 (Multivariate HLM Concert Dataset 3) 192

E.3 M3 (Multivariate HLM Concert Dataset 3) 192
E.4 M4 (Multivariate HLM Concert Dataset 3) 193
E.5 M5 (Multivariate HLM Concert Dataset 3) 193
E.6 M6 (Multivariate HLM Concert Dataset 3) 193
E.7 M7 (Multivariate HLM Concert Dataset 3) 194
E.8 M8 (Multivariate HLM Concert Dataset 3) 194
E.9 M9 (Multivariate HLM Concert Dataset 3) 194
E.10 M10 (Multivariate HLM Concert Dataset 3) 195

List of Figures

4.1 Photographs of the rock concert (Concert Dataset 1) . . . 41
4.2 A participant wearing the two devices on the arm and torso. . . . 42
4.3 Overview of the experimental procedure and data collection process . . . 44
4.4 Estimated marginal means of movement entrainment (Concert Dataset 1) . . . 45
4.5 Comparisons of movement entrainment calculated for target and control BPM values (Concert Dataset 1) . . . 47
4.6 Photographs of the audience in the seated and standing conditions during the big band concerts (Concert Dataset 2) . . . 50
4.7 Photograph of the big band performing in one of the two concerts (Concert Dataset 2) . . . 51
4.8 Main effects predicting Movement Entrainment . . . 61

5.1 The structural equation model predicting Social Experience of the Concert . . . 71
5.2 Mediation model with the effect of Standing (vs. Sitting) on Attention mediated by Movement Entrainment . . . 72
5.3 Photographs of the indie-pop concert (Concert Dataset 3) . . . 82
5.4 Correlation matrix of all pro-group thinking items and Movement Entrainment . 87
5.5 Interaction effect between Active Musical Engagement and the target of Social Connection . . . 91
5.6 Main effects predicting Social Connection . . . 92

6.1 Overview of the main findings of this thesis . . . 100

A.1 Example raw data for the whole concert . . . 130
A.2 Example raw data detail . . . 131
A.3 Workflow of the analysis . . . 132

C.1 Estimated marginal means of movement entrainment (Concert Dataset 2) . . . 148

E.1 Estimated marginal means of movement entrainment (Concert Dataset 3) . . . 189

E.2 Comparisons of Movement Entrainment calculated for target and control BPM values for Concert Dataset 3 190
E.3 Correlations between Movement Entrainment and participants' self-reports of Movement to the Music and Movement with Other Audience Members 191

List of Abbreviations

BPM	beats per minute
CFI	Comparative Fit Index
CI	confidence interval
Df	degrees of freedom
EDM	electronic dance music
EEG	electroencephalogram
Gold-MSI	Goldsmiths Musical Sophistication Index (Müllensiefen et al., 2014)
HLM	hierarchical linear model
IOS	Inclusion of Other in the Self (Aron et al., 1992)
M	mean
MLR	Maximum Likelihood Robust
NA	Negative Activation
PA	Positive Activation
PANAVA-KS	Positive Aktivierung Negative Aktivierung Valenz-Kurzskalen, engl.: Positive Activation Negative Activation Valence' scale, short version (Schallberger, 2005)
SD	standard deviation
SE	standard error
SECS	Social Experience of a Concert Scale (O'Neill & Egermann, 2022)
SEM	Structural Equation Model
SRMR	Standardised Root Mean Square Residual
TLI	Tucker–Lewis Index
VA	Valence
WLSMV	Weighted Least Squares Mean and Variance
χ^2	chi-square

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1 Introduction

Music is a universal feature of human culture, present in all known societies and integral to everyday life. Its enduring presence, with roots dating back to prehistoric times, reflects its deep cultural significance and long evolutionary history (Merriam, 1964; Mithen, 2005; Zatorre, 2001). Far from being a mere aesthetic pleasure, music is fundamentally a social phenomenon, typically performed and experienced with others in live settings (Freeman, 2001; Nettl & Russell, 1998). Therefore, music has always brought people together. Even in an era of individualised music consumption, its social function remains central (Hargreaves & North, 1999). This social dimension is particularly evident in live concerts – environments in which people come together in shared physical spaces, and in which music is not merely heard, but collectively experienced.

As music is such an ancient and widespread phenomenon, numerous theories have been proposed regarding its origins and how it has survived and developed over hundreds of thousands of years. A prominent hypothesis posits that one of the main functions of music-making is to promote pro-group outcomes, such as group solidarity, social cohesion and co-operation, by synchronising movements and emotional states (e.g., I. Cross, 2016; Dunbar, 2012; Huron, 2001) and that this also supports the assumption that music is an evolutionary adaption (Freeman, 2001; McNeill, 1995; Savage et al., 2021; Trainor, 2015). Empirical evidence underpins this idea: joint music-making, singing, and rhythmic coordination have been widely shown to enhance social bonding and pro-group social behaviour (e.g., Kreutz, 2014; Pardo-Olmos et al., 2025, for a review).

Furthermore, live concerts provide a natural context for such synchrony. Evidence shows that concerts evoke synchronised responses across multiple levels – subjective (e.g., shared emotion; Egermann et al., 2013), physiological (e.g., heart rate; Czepiel et al., 2021), and behavioural (e.g., movement; Swarbrick et al., 2019). Among these, movement to music is not only one of the most visible responses, but also one of the most natural human reactions even observable in infants (Zentner & Eerola, 2010). The synchronisation of body movements to an external stimulus such as music is called movement entrainment. Examples include swaying, head nodding, clapping, or dancing to the music (Godøy & Leman, 2010). They are an integral part of the experience of music and concerts (e.g., Leman, 2008; McNeill, 1995;

Turino, 2008) and in some cultures, music and dance are not even considered to be separate cultural categories (Merriam, 1964). Since synchronised movement to music is such an important aspect of music reception and the experience of concerts, it is reasonable to expect a positive effect of joint movement to music on pro-group outcomes in the context of concerts as well. However, most studies that found positive relationships between joint movement and pro-group outcomes like social connection, likeability, feelings of trust and similarity have been conducted mainly in controlled laboratory environments, often involving artificial tasks or small groups (e.g., Hove & Risen, 2009; Tarr et al., 2016; Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009). Crucially, no study to date has empirically examined whether audience movement entrainment during live concerts is associated with measurable outcomes of their social concert experience. Given the strong theoretical and empirical links between synchronous movement and pro-group outcomes it seems highly plausible, however, that this positive relationship can also be found during live concerts and that joint movement does have a positive impact on social audience experience, including pro-group outcomes – both among audience members as well as between the audience and the musicians. Furthermore, other variables may influence both movement entrainment and the social concert experience.

Due to a lack of empirical research on movement entrainment and social audience experience in live concerts, this thesis investigates 1) how joint movement can be measured in an ecologically valid concert setting, as well as contributing factors, 2) the effect of a seated versus an unseated concert format on movement entrainment and general as well as social audience experience, and 3) how movement entrainment and further contributing variables are related to the audience's social concert experience. A multimodal approach was employed that combined subjective experience data from questionnaires with objective movement data collected via an audience response system in real-world concerts. The measuring devices were very small and lightweight and did not restrict the participants' movements, to keep the study as ecologically valid as possible.

While music and live performances can be described as universal phenomena, concert cultures and the performance of music vary significantly across regions and traditions (e.g., Turino, 2008). This thesis focuses specifically on rock, pop, and jazz concerts within a Western cultural context (recognising that jazz does not, of course, have its origins in Western culture), a choice motivated primarily by practical considerations. In these genres, bodily movement in response to music is embedded in the cultural framework of the performance experience – often encouraged and expected – unlike in many classical Western concert traditions, for example, in which audience movement is typically discouraged or even considered inappropriate. As the presented studies were conducted in Germany, the vast majority of participants came from a Western cultural background, too.

Following a review of the relevant literature on the theoretical and empirical foundations of collective audience responses during concerts, with a focus on collective movement entrainment reactions and social concert experience, two chapters will present three sets of empirical concert data. The first dataset was used to test whether audience movement entrainment can be measured in an ecologically valid concert setting. The second explores factors contributing to audience movement entrainment. An experimental condition was added to introduce more variability into movement entrainment: In one condition, the concert hall was equipped with seats and the audience sat during the concert; in the other condition, there were no chairs and the audience experienced the concert standing. This dataset is also used to investigate the effect of standing compared to sitting at concerts on the general and social concert experience. The third dataset investigates the effects of movement entrainment on the audience's social experience, alongside other potential influencing variables. Finally, the thesis concludes with a general discussion of the main findings and an outlook on potential avenues for future research.

2 Background

This chapter establishes the theoretical and empirical foundation for the studies presented in this thesis. It reviews relevant literature, introduces key theoretical frameworks, and outlines the current state of research in the field. The objective is to provide the conceptual basis for the research questions and methodological approaches employed in the subsequent empirical chapters. This background chapter is organised into four sections. The first section examines general collective and synchronised audience responses during live concerts. The second section builds on this by highlighting collective movement entrainment as a central phenomenon, describing its characteristics, measurement in concert settings, and key influencing variables. The third section explores collective social audience experiences at concerts, including their emergence, measurement, and contributing factors. Finally, the fourth section establishes the theoretical and empirical basis for the relationship between movement entrainment and social concert experience by integrating the two concepts.[1]

2.1 Collective Responses in Concert Audiences

A multitude of studies have shown how synchronised and coordinated audience responses arise as shared experiences during concerts. In these studies, multiple emotional response components have been continuously measured in audiences throughout concerts. Each component represents a different aspect of emotion, as conceptualised by the Component Process Model of Emotion presented by Scherer (2005). According to this model, emotions are dynamic episodes involving synchronised changes across five subsystems:

- the cognitive appraisal component, measured through continuous ratings of expectation (e.g., Egermann et al., 2013);
- the motor expression component, measured through facial expressions (e.g., Kayser et al., 2022);

[1] Parts of the present chapter have been published with some adaptations and in a different format as Hochgesand and Egermann (2025) and Hochgesand and Egermann (2026).

- the physiological arousal component, measured through skin conductance and heart rate (e.g., Egermann et al., 2013);
- the motivational component, measured through synchronised audience movements (Swarbrick et al., 2019), singing along, or clapping and applause (Mann et al., 2013; Toelle, 2018);
- the subjective feeling component, measured through continuous and retrospective ratings of valence and arousal, as well as basic and aesthetic emotions (e.g., Chabin, Gabriel, Comte, Haffen et al., 2022; Chabin, Gabriel, Comte & Pazart, 2022; Egermann et al., 2013; Kayser et al., 2022).

These components interact in response to a stimulus, such as music, and together shape the audience's emotional experience.

One group of studies shows that musical characteristics and events elicit coordinated audience responses across some of these emotion components (Upham & McAdams, 2018). These responses are related to violations of expectation (Egermann et al., 2013) or the specific expressive qualities of happiness and sadness, which have been shown to induce corresponding facial expressions in audiences (Kayser et al., 2022). Furthermore, the rhythmic structure of live music has been shown to induce synchronised body movements measured on audience heads (Swarbrick et al., 2019).

Another group of studies has examined interpersonal synchronisation and alignment between audience members. At these concerts, experimenters assessed the degree of synchronisation among different audience members, measured across the same response components. This stands in contrast to the experiments presented in the previous paragraph, which tested for synchronisation and alignment between music and the audience.

Chabin, Gabriel, Comte, Haffen et al. (2022) showed that at an international competition of conductors, the electroencephalograph (EEG) recordings from 15 audience members were aligned to some degree (see also Chabin, Gabriel, Comte & Pazart, 2022). This cerebral coherence was larger when participants were sitting closer to each other, but only when they reported similar felt emotions or high levels of pleasure, as assessed via continuous ratings. This suggests that emotion induction mechanisms (Juslin & Västfjäll, 2008) were also operating during similar musical events at the concert, creating similar emotional experiences. Czepiel et al. (2021) have shown that peripheral arousal measures of audiences synchronise at concerts, as measured via intersubject correlation of heart and respiration rate and skin conductance (see also Czepiel et al., 2025). Audience physiology was synchronised at different types of musical events: increased tempo, transitional passages, boundaries between formal sections, and phrase repetitions (Czepiel et al., 2021).

Using a different measure of audience synchrony (Surrogate Synchrony, SUSY), Tschacher, Greenwood, Egermann et al. (2023) also reported significant synchronisation of changes in heart and respiration rate, as well as in skin conductance responses, averaged across musical bars. There was a positive association between dyad-wise participant synchrony in skin conductance and respiration rate and rated appreciation of the music presented in the concert. Tschacher, Greenwood, Ramakrishnan et al. (2023) and Tschacher, Greenwood et al. (2024) replicated the overall audience synchronisation effect of heart rate, respiration rate, and skin conductance at two additional concerts. However, results regarding the association between retrospective audience ratings of music and the concert experience were mixed (sometimes it was associated with ratings of aesthetic emotions and appreciation, and sometimes it was not). Tschacher, Greenwood, Ramakrishnan et al. (2023) also reported synchronised audience movements, employing a birds-eye camera setup to quantify co-occurring pixel changes between different pairs of participants. This was achieved using Motion Energy Analyses, which could represent any body movement that happens at a similar time (see also, Seibert et al., 2019).

While these studies suggest that audience responses at concerts exhibit similarity at the subjective, physiological, and behavioural (movement and expression) levels, this chapter now focuses on two phenomena that are particularly significant at concerts: collective movement entrainment and social concert experience.

2.2 Collective Movement Entrainment Reactions at Concerts

Music makes people move, whether we are in a club, doing a waltz, or simply listening to a song on the radio, music can make us dance spontaneously. Moving our body to the beat is one of the most natural human reactions while listening to music. This urge to move to music can be explained with connections between the brain's auditory and motor regions (e.g., Fujioka et al., 2012; Grahn & Brett, 2007; Janata & Grafton, 2003; Janata et al., 2012; Sakai et al., 1999). Several studies have shown that motor areas of the brain are activated when participants listen to different beats even without intending to move (Zatorre et al., 2007), or when pianists observed piano playing (Haslinger et al., 2005). This motor activation is thought to arise from the synchronisation of neural oscillations to the temporal structure of rhythmic stimuli, enabling the generation of dynamic predictions of upcoming beats that, through reciprocal connections between auditory and motor networks, support and predispose coordinated movement aligned with the rhythm (e.g., Large et al., 2023).

Particularly during concerts in the pop or rock genre, attendees often engage in movement like clapping, head nodding, feet tapping, swaying, and dancing to the music (Godøy & Leman, 2010). Some people feel the need to move in synchrony with the music (Lesaffre

et al., 2008; Phillips-Silver et al., 2010), and some pieces make people want to move. The song "In the Stone" by Earth, Wind & Fire, which will later play a role in this thesis, was once described as an "irresistible dancing cut" that "moves to a swinging mixture of catchy percussives and intricately woven harmonies" in a contemporary music magazine (Anonymous, 1979). This designation refers not only to the danceable quality of the piece, but also to the impact that music exerts on dancing behaviour. In some cultures, music and dance are no separable cultural categories at all (Merriam, 1964) and this close connection between music and dance has led to the hypothesis that the two have evolved together over time (I. Cross, 2001; I. Cross, 2008).

2.2.1 Foundations of Movement Entrainment

The synchronisation of bodily movements to music can be defined as movement entrainment. Entrainment has been described as the process in which two (or more) independent rhythmical, biological, or mechanical systems attune each other resulting in coordinated rhythmic behaviour (Clayton, 2012; Phillips-Silver et al., 2010). Many rhythmical processes are continuous and have a periodic reference point such as a beat or a foot tap. This is why the concept of phase, imagined as a 360° circle, can be applied. If two such events occur simultaneously, the rhythms are in-phase (relative phase 0°); if one event happens exactly halfway between the other, they are in anti-phase (relative phase 180°), etc. When two systems are entrained, they do not need to be perfectly in-phase, but rather exhibit a stable and consistent relative phase (e.g., in-phase, anti-phase, or somewhere in between). Further, the key evidence for entrainment is not just this stability, but also the system's ability to re-establish the same phase relationship after being disturbed (Clayton, 2012).

In the context of human movement, movement entrainment can refer for example to the synchronisation with another person (also called social or interpersonal entrainment; Clayton et al., 2005; Phillips-Silver et al., 2010), or with an external stimulus such as music. At a concert, the music played by the musicians can be defined as the external auditory stimulus. As everyone in the audience listens to the same music, it is likely that the audience moves in synchrony to the performed pieces. This can also be described as asymmetrical entrainment (Clayton et al., 2005), given the audience's limited or negligible influence over the musical stimulus.

Music contains numerous recurring structures (e.g., a beat structure) that allow listeners to perceive a periodic stable pattern and to synchronise their movements to it (Large, 2000). Movement entrainment to the beat of the music requires the ability to detect these rhythmic signals in the music, to produce rhythmic information such as rhythmic movement, and also to alter the rhythmic movement based on the perception of rhythmic signals of the music

(Phillips-Silver et al., 2010). The ability to synchronise movements with a musical beat has mostly been investigated with finger tapping studies, in which participants were asked to tap in time with a metronome or musical beat (for a review, see Repp, 2005; Repp & Su, 2013).

Research suggested that there is a general preferred tempo of 120 beats per minute (BPM), which is considered to be optimal and most natural for perception (Moelants, 2002). In this context, it is possible to draw links to the natural human walking tempo, as the spontaneous duration of steps was found to be around 500–550 milliseconds, which corresponds to a tempo between 110 and 120 BPM (Fraisse, 1982; MacDougall & Moore, 2005; M. P. Murray et al., 1964; Van Noorden & Moelants, 1999). According to these considerations, it could be assumed that music with tempi between 110 and 120 BPM stimulates more movement entrainment – i.e. synchronous movement to the beat of the music – than music with slower or faster tempi. However, there is also evidence that the tempo of the music has no influence on movement features of participants (Burger et al., 2014) and that also the preferred tempo varies across individuals and age groups (McAuley et al., 2006).

While listening to music, we often perceive not just one isochronous pulse, but several beat levels. The organisation of these beat levels is typically hierarchical, wherein one level can be described as an integer multiple of the other level (Palmer & Krumhansl, 1990). The interaction between these different beat perceptions leads to the perception of a periodic alternation of strong and weak beats, which corresponds to the generally accepted definition of musical meter (Jackendoff & Lerdahl, 2006). The metrical structure usually derives from the accent structure of the music, which in turn depends on various characteristics such as loudness, duration, and the pitch of single tones or changing harmonies (Toiviainen et al., 2010). Most Western music has either a duple (accent on every second beat) or a triple meter (accent on every third beat; Toiviainen et al., 2010). Research focusing on synchronisation of movements to different metrical levels found that participants embody different metrical levels of musical stimuli with different body parts (Burger et al., 2013; Burger et al., 2014; Toiviainen et al., 2010). This bodily synchronisation to music can already be found in infants and the observation that even young children react to music and metrical stimuli with more rhythmic movements than to speech indicates that humans have a predisposition for rhythmic movements to music and regular metrical sounds (Zentner & Eerola, 2010).

Bodily movement to an external stimulus such as music represents the fundamental principle in embodied cognition theory, which argues that physical processes are integral to or even essential for cognitive processes (Leman, 2008; Varela et al., 1991). According to this theory, movement in response to music reflects, imitates and enhances our understanding of it. Leman (2008) identifies three (co-existing) conceptual components that influence corporeal articulations: "Synchronisation", "Embodied Attuning", and "Empathy". These components vary in their degree of musical engagement. "Synchronisation" represents the funda-

mental component, involving alignment with the musical beat, a process that is effortless and spontaneous, with the beat serving as the basic musical element for synchronisation. "Embodied Attuning", the second component, addresses the connection between body movement and musical characteristics that extend beyond the basic beat, encompassing elements such as melody, harmony, rhythm, or timbre. The third component, "Empathy", links musical characteristics to emotional expression, whereby listeners experience, feel, and identify with the emotions conveyed in the music, subsequently expressing and mirroring these emotions through their physical movements.

Music is a widespread social phenomenon, typically performed and experienced in live settings (Freeman, 2001; Nettl & Russell, 1998). Therefore, it can be claimed that one of the most suitable settings to study movement entrainment would be a live concert. However, most of the previous research instead studied body movement and dancing in laboratory studies or in settings with atypically small groups (Bamford et al., 2023; Burger et al., 2010; Burger et al., 2013; Burger et al., 2014; Burger & Toiviainen, 2018; Saarikallio et al., 2013; Solberg & Jensenius, 2017; Solberg & Jensenius, 2019; Tarr et al., 2016; Tarr et al., 2015). A study investigating head movements during a rock concert seated their participants (Swarbrick et al., 2019) which might have resulted in limited movement and did not allow for dancing. The studies in the context of classical concerts cannot be considered adequate either, as the socio-cultural context tends to inhibit movement (Seibert et al., 2019).

Studying movement entrainment in an ecologically valid concert setting, in which a large audience can move freely throughout the venue, introduces several methodological challenges. Therefore, the next section outlines the measurement techniques that can capture movement entrainment under these realistic conditions.

2.2.2 Measuring Movement Entrainment at Concerts

The two most common methods of measuring human movement are motion capture and the use of inertial sensors, such as accelerometers. This section briefly introduces these methods and relevant studies in the context of movement to music and concerts, in which the methods were employed. If the studies measured movement entrainment, the analysis procedure is also summarised.

Solberg and Jensenius (2016) have carried out a comparison between motion capture and inertial sensors for studying group movement to electronic dance music. Their findings can be applied to research on audiences at live concerts:

Motion Capture

Motion capture is a well-established method to measure movement. It can be done with or without markers. When markers are used, multiple cameras are typically positioned around

the capture space and participants wear reflective markers on their bodies. Infrared cameras enable tracking in poorly lit rooms, and the markers allow the tracked joints to be located with high spatial and temporal accuracy. However, each marker must always be tracked by a camera. Therefore, only a limited number of people can be measured at the same time; otherwise, when people stand or dance too close together, there is an increased risk that the markers will be obscured and will no longer be trackable. To measure accurately, the system must be calibrated. For this reason, it is best used in a fixed setting, such as a laboratory. The system is also sensitive to reflections, which can be caused by buttons on clothing or glass bottles, for example (Solberg & Jensenius, 2016). Studies in the field of dance research have applied this method to measure dance moves of one person at a time in laboratory environments with no other participants present (e.g., Burger et al., 2013; Burger & Toiviainen, 2018) and also in small groups to investigate interpersonal coordination in dance (e.g., Bamford et al., 2023; Solberg & Jensenius, 2017; Solberg & Jensenius, 2019).

The study by Swarbrick et al. (2019) recorded head movements with markers placed on caps worn by the participants. The study took place in a seated concert hall equipped with a motion capture setup specifically for research purposes. The authors analysed, among other variables, a degree of entrainment, defined as how frequently participants entrained their head movements to the beat of each song. They analysed the head motion trajectories using windowed autocorrelation (10 s window size, hop size of 5 s, and lags ranging from 0 to 2 s) to extract movement periodicities. Quarter, half, and whole note levels were derived from the musical metrical hierarchy of each piece. For each 10-second window, entrainment was defined as a match within ±5% of one of these tempi. The general degree of entrainment was then computed as the number of windows showing entrainment. While the use of motion capture allowed for precise measurement of head movement dynamics, the study's design – in which participants were seated during a rock concert – may have constrained naturalistic movement. However, seating participants simplified motion capture by reducing marker occlusion and ensuring stable tracking.

The markerless approach used by Tschacher, Greenwood, Ramakrishnan et al. (2023) has already been mentioned. It measures interpersonal synchrony based on Motion Energy Analysis (Ramseyer & Tschacher, 2011) of video recordings. Regions of interest (ROIs) are defined for each audience member, with pixel changes between consecutive frames serving as a proxy for movement intensity (see also Seibert et al., 2019; Tschacher, Tröndle & Weining, 2024).

More accurate markerless motion capture is constantly being developed and has recently been used in the context of sports science and motion analysis (Büning et al., 2025; Steinberg et al., 2025).

Inertial Sensors

Like markers for motion capture, inertial sensors are attached to participants' bodies. However, based on a different technical and physical approach, they measure the positional displacement (accelerometers) and rotation (gyroscopes) of a proof mass. These sensors rely on gravity, making them robust to lighting and environmental conditions. They offer high sampling rates, low power consumption, and can be installed in small devices such as smartphones and smartwatches. It is possible to estimate the position of participants wearing sensors through a combination of data from gyroscopes and magnetometers. However, to mitigate drift, additional sensors or cameras have to be added (e.g., Kok et al., 2017; Solberg & Jensenius, 2016) or special conditions are required (e.g., Tautges et al., 2011).

A study by Ellamil et al. (2016) used accelerometer data from a smartphone application to measure interpersonal phase synchronisation of participants' movement in a real dance club scenario as a measure of group synchrony.

Swarbrick and Vuoskoski (2023) also used accelerometer data derived from an application installed on participants' smartphones. This allowed the researchers to measure not only the movement of the audience in the concert hall, but also that of the audience watching a live stream of the string quartet performance at home. The authors analysed quantity of motion for each participant, representing the relative amount of time a participant spent moving, and stilling behaviour, the alignment of stilling with the music (Upham & Rosas, 2025; Upham et al., 2024).

Two further studies (Irrgang & Egermann, 2016; Irrgang et al., 2020) applied a Fast Fourier Transform to smartphone accelerometer recordings, extracting spectral features such as the dominant frequency and its magnitude of free, spontaneous movement to music. This approach could also be employed to quantify the degree of beat entrainment.

In conclusion, this brief overview shows that the measurement of movement entrainment in live concerts involves a trade-off between precision and ecological validity. Optical motion capture offers high accuracy in controlled settings but is impractical in real-world environments due to its reliance on fixed cameras and marker-based line-of-sight tracking. These constraints limit its use in large, dynamic concert settings. In contrast, inertial sensors provide a scalable, non-invasive, and ecologically valid alternative that can also be used with large audiences. Additionally, they can be a very inexpensive choice when participants use their own smartphones. Therefore, to measure movement entrainment of audiences in an ecologically valid concert setting, inertial sensors seem to be the best option. Video-based tracking could be used as a complimentary measure. As the technologies inherently favour different approaches to analysing the collected data, the choice depends on the given research question.

Having outlined the technological possibilities for gathering relevant data, the following section will focus on the variables that potentially influence movement entrainment.

2.2.3 Variables Influencing Movement Entrainment

Listeners reactions to music have been discussed as the result of the music, the context, and the listener by various researchers: Scherer and Zentner (2001) propose that the emotional responses to music are influenced by four primary factors: structural features, performance features, listener features, and contextual features. Proposing a similar reciprocal-feedback model of musical response, Hargreaves (2012) describes how the music, the situation and context, and the listener interact and finally lead to a response. The importance of the listening situation on musical preference was emphasised by North and Hargreaves (1996).

In the context of concerts, the aesthetic experience of music is presented as the encounter of an individual person with a piece of music (sound) in a specific situation or concert frame (Wald-Fuhrmann et al., 2021). The concert frame encompasses environmental, aesthetic, social and situational properties of a concert. These could, for example, include the venue, staging, lighting and sound.

In light of this multifaceted interplay, it appears reasonable to suggest that movement entrainment is also not solely driven by rhythmic properties of the music. Rather, it depends on the music itself, the concert-frame (i.e., the contextual setting), and the individual listener.

Musical Factors

Research has examined several effects of musical factors on movement to the music and movement synchrony. A study by Luck et al. (2010) demonstrates that the genres Latin, Techno, and Rock elicit different characteristics of movement. Additionally, findings by Burger and Toiviainen (2018) reveal that electronic dance music (EDM) evokes more movement than genres like Latin, Funk and Jazz. Results by Solberg and Jensenius (2019) and Solberg and Jensenius (2017) indicate that certain musical passages of EDM increase beat synchronisation and group synchronisation of dancers in an club setting. Further, musical features of pulse clarity, beat predictiability, percussiveness, moderate degrees of syncopation, rhythmic complexity, the density of events between beats, high spectral flux (measure of the variability of the frequency spectrum over time), and bass frequencies are also known to evoke more movement – at least in certain parts of the body (Burger et al., 2010; Burger et al., 2013; Dyck et al., 2013; Fitch, 2016; Hove et al., 2020; Madison et al., 2011; Witek et al., 2014). Microtiming, minute temporal asynchronies, being characteristic of swing and funk music, may also have an impact (Kilchenmann & Senn, 2015). It was further found that even very low frequencies that are near or below the hearing threshold can increase dancing at an EDM concert (Cameron et al., 2022).

Contextual Factors

The impact of specific components of the concert frame on concert experience has lately been studied in the context of Western classical music (Wald-Fuhrmann et al., 2026). This research highlights the importance of the concert frame and how situational factors influence the concert experience. Swarbrick et al. (2019) compared a band's live concert with a "playback" concert without the performers at which the same songs were played from a recording. They found that audience members move their heads significantly faster during the live performance than during the pre-recorded version.

Additionally, it is reasonable to expect that generally, a standing or dance-friendly venue would permit greater body movement and thus stronger entrainment to the music. In contrast, a seated configuration would impose physical constraints that would limit such responses. Beyond the layout of the venue, it was found that people move more when moving together (De Bruyn, Leman & Moelants, 2008; De Bruyn, Leman, Demey et al., 2008). It is therefore possible that there is also a type of contagion effect. Furthermore, the socio-cultural context and the specific concert culture are likely to shape movement entrainment. Certain genres of music and the associated performance practices integrate body movements and dance as central components of the experience. Attendees at rock and pop concerts, schlager music or folk music performances often synchronise their movements, such as swaying, head nodding, dancing or clapping, to the rhythm of the music. Electronic dance music is a musical style dedicated to dancing (Collins et al., 2013), and metal concerts are characterised by intense physical engagement (Silverberg et al., 2013; Suer, 2023).

Personal Characteristics

In addition to the music itself and the context, there are also indications that personal characteristics of the listeners have an effect on movement entrainment. Luck et al. (2010) report effects of personality traits on music-induced movement. It was further found that people in a positive mood move more, faster, and with more complex movements than other people (Saarikallio et al., 2013), and another study suggests a positive association of the trait empathy and rhythmic entrainment while moving to music (Bamford & Davidson, 2017). This finding is also supported by Zelechowska et al. (2020), who report that empathic concern predicts spontaneous movement to music. Furthermore, Swarbrick et al. (2019) observed in their aforementioned study more vigorous head movements and more entrainment by fans of the performing band compared to neutral listeners. This suggests that liking a band or their music might increase movement entrainment. The positive reaction of experiencing the musicians could also contribute to such a positive evaluation. The club study by Ellamil et al. (2016) found a positive association between movement and familiarity with the music.

It is further conceivable that people with a higher degree of dance sophistication (Rose et al., 2022) will move and dance more.

Taken together, the evidence reviewed above indicates that audience movement entrainment at concerts cannot be attributed to a single cause; rather, it emerges from the interplay of musical properties, situational variables that define the concert frame, and personal characteristics of the listeners. Having outlined the mechanisms of entrainment, the methods for measuring it in live performances, and key influencing variables, the next section turns to the collective social experience of live concerts.

2.3 Collective Social Experience at Concerts

Social experience is a fundamental factor in leisure participation (Beard & Ragheb, 1983) and plays a particularly crucial role in the appeal of live concerts as a preferred musical experience (Krause et al., 2020). The opportunity to engage with like-minded people and experience social connection serves as a key motivation for concert attendance (S. C. Brown & Knox, 2017). Concerts can create a "sense of unity" with other audience members as well as between the audience and the performers (Tarumi et al., 2017). But how does this social connection arise? How may a concert influence the way audience members feel and think about other people in the audience and the musicians?

To address these questions, this section first presents foundational theories relevant to collective social audience experience at live concerts. The concept of social connection is introduced and explored as a central construct to describe the affective outcomes of concert attendance, namely, the subjective experience of belonging, or relating to others, because this concept has been frequently used in empirical research and offers conceptual clarity. This is followed by an overview of methods for measuring the social experience of concerts. In the final part of this section, empirical findings on factors influencing the social experience of a concert will be reviewed.

2.3.1 Theoretical Perspectives on Social Experience at Concerts

There is currently no single theory that fully explains how this sense of social connection arises among audience members and between them and the musicians during concerts. It is therefore necessary to draw on a range of theories, primarily general theoretical approaches from social psychology, that were not developed specifically in the context of concerts, such as research on affiliation, attraction and close relationships, and group theory. The order in which these concepts are presented does not imply any hierarchy of importance but

rather aims to highlight their interrelations in explaining the social dimension of live concerts. Where available, concrete evidence from musical contexts supplements and supports the more general approaches.

Notably, some of the social phenomena discussed are not unique to concerts. These effects can be observed in a wide range of shared experiences in which people are physically or virtually present together and engage in the same event. This includes sporting events, public gatherings, and everyday situations such as sharing a live stream or watching a video in a group (e.g., Wolf & Tomasello, 2020).

In addition to generally applicable concepts, the theoretical approach that guided the creation of a dedicated social concert experience scale will be outlined. Finally, the concept of social connection will be established as a central phenomenon of social concert experience.

Similarity

When looking at the social experience of audience members during concerts, one essential aspect is similarity. Despite their potentially different backgrounds, concertgoers share a number of commonalities: They have chosen to gather at a specific location and time to listen to the same performance; they may have the same favourite band or at least enjoy similar music; and they may live in the same town.

Musical preferences correlate with values and personality (Rentfrow & Gosling, 2003), so concertgoers could assume that they share not only the same musical preference with the other attendees, but also similar personality traits or values. The relationship between musical preference and social attraction has been studied by Boer et al. (2011). They found that this link can be explained with similarity in value orientation: Music preferences can be an indicator for similar value orientation, and similar values lead to social attraction.

More generally, social psychology has shown that similarity is a powerful factor in fostering attraction and friendships (Buunk & Dijkstra, 2008). The similarity-attraction effect describes the tendency of individuals to be drawn to people who are similar to them. Attraction, in this context, refers not only to physical attraction, but also to the feeling of liking someone or wanting to be around them (Reis, 2007). People who are similar to us tend to confirm our beliefs and opinions, and share our values (Newcomb, 1961), leading to positive emotional reactions (Byrne, 1971). Furthermore, people assume that someone who is 'like them' will accept and understand them, and be able to satisfy their needs (S. L. Murray et al., 2002). Similar individuals are also more familiar and predictable, as they evoke a sense of recognition, reduce uncertainty, and facilitate communication (Berger & Calabrese, 1975; Karremans & Finkenauer, 2023).

It stands to reason that the described effects also occur in musical contexts such as concerts, both among audience members as well as between audience members and the performing musicians.

Groups, Shared Attention and Shared Experience

Similarity does not only lead to liking or social attraction, it also plays a crucial role in shaping group membership (Lickel et al., 2000). Shared group membership and group identity, in turn, have the capacity to bond people together and influence how individuals think and behave towards others (e.g., Tajfel, 1970). Group identities can emerge easily and quickly, even when based on minimal or arbitrary criteria (Tajfel, 1970; Tajfel et al., 1971). Thus, people respond more positively towards their in-group members compared to out-group members (Hewstone et al., 2002). People also feel more empathy for members of their in-group and are more likely to help them compared to out-group members (Stürmer et al., 2005; Stürmer et al., 2006). This difference in attitudes towards in-group members and out-group members is referred to as in-group favouritism and out-group bias (Tajfel & Turner, 1979). Particularly for adolescents, music plays an important role in peer group processes and shaping an identity (Tarrant et al., 2001; Tarrant et al., 2002).

A shared focus of attention, as is normally the case with concert audiences, can also lead to a feeling of being part of a shared group (Tajfel et al., 1971). Cochrane (2009) focuses on joint attention at concerts, claiming that it fosters a sense of community among audience members, even when they do not interact directly. Further, Frith (1996) and Wheatley et al. (2012) argue that sharing experiences, such as attending a concert together, can form a shared identity, which in turn can foster feelings of connectedness and liking each other (Pinel et al., 2006).

In the context of a concert, it stands to reason that every audience member is part of a common group: the collective audience. This collective identity arises not only from shared preferences or a common affinity for the band, but also from their shared status as audience members, connected by the shared experience of attending and participating in the live event. However, the performers occupy a distinct position, typically physically separated from the audience by the stage, which can create a sense of distance and distinction. Nevertheless, both the musicians and the audience are united in their shared participation in and experience of the concert, a unique event that will never be replicated in the same form. Therefore, it stands to reason that the shared experience of the concert shapes not only the relationship between audience members, but also that between the audience and the musicians.

Theory of Collective Mind

The theory of collective mind proposed by Shteynberg et al. (2023) offers a general, comprehensive framework for understanding how a shared, collective mental state can emerge beyond individuals, which also can lead to social bonding. Developed within the disciplines of cognitive science and social psychology, this theory also builds on shared attention as well as experiences, and may be applied to concert audiences. The authors describe the "collective mind" as a unified mental state that can arise when individuals share similar experiences and perspectives. In such moments, people not only pay attention to the same external reality, such as a concert performance, but also recognise that they are sharing the experience with others. This shared awareness can foster feelings of closeness and increase affiliative behaviour. According to the authors, when individuals feel confident that they perceive the world in the same way as others around them, it strengthens social bonds and can support future cooperation. These effects are particularly strong when the group itself, such as a concert audience, is recognised as an important part of the experience. In a concert setting, for instance, listeners share the experience of being present in the same space and enjoying the same music while also identifying with the goal of having an enjoyable time together.

Social Experience of a Concert

O'Neill and Egermann (2022) have specifically focused on the social experience of a concert and how it can be measured. With their Social Experience of a Concert Scale (SECS), the authors developed the first validated measurement instrument to capture social experience of live concert audiences. The scale was created and validated based on data from surveys conducted during Western art music concerts and it consists of 17 items representing a five-factor model.

The authors based their model on two central theoretical perspectives: firstly, the extent to which individuals direct their attention towards other audience members, informed by parasocial interaction theory (Horton & Wohl, 1956; Rubin & McHugh, 1987; Schramm, 2015); and secondly, the extent to which individuals identify with fellow audience members, informed by in-group theory (Alport, 1954; Sherif, 1967; Tajfel, 1981; Tajfel & Turner, 1979).

Parasocial interaction theory initially refers to the interaction between a viewer and a television persona, whether that persona is a fictional character or a real individual (Horton & Wohl, 1956). Such relationships have a non-reciprocal nature, meaning information flows only in one direction, from the persona on television to the audience member. The authors argue that, particularly in the context of Western art music concerts, interactions among audience members can be understood as a form of parasocial interaction due to the convention of remaining silent and avoiding interaction (O'Neill & Egermann, 2022; Wilson et al., 2014):

Even though an audience member can observe the behaviours and reactions of other audience members, they cannot react or respond to them directly in the moment (O'Neill & Egermann, 2022). Therefore, the authors based part of their questionnaire on an established instrument for assessing parasocial interaction, the PSI Process Scales by Schramm and Hartmann (2019). The PSI Process Scales consists of 14 scales with eight items each. Six of the subscales are representing cognitive parasocial responses, five of them affective parasocial responses, and another three behavioural parasocial responses. O'Neill and Egermann (2022) only used scales and items they perceived to be relevant to their study in the context of a concert: 1) items representing cognitive parasocial responses from the Persona-Specific Information Reception scale (including items related to Depth of Information Processing and Vividness of Recall, and Attention) and the Evaluation of Persona and His/Her Actions scale; 2) items representing affective parasocial responses from the Sympathy scale, the Antipathy scale, and the Emotion Release scale (including items related to Emotion Contagion and Emotion Induction); and 3) items representing behavioural parasocial responses from the Nonverbal Behaviors scale (including items related to Mimicry and Gestures) and (excluding one item) Behavioral Intention scale (Schramm & Hartmann, 2019).

With the second theoretical approach of the SECS the authors wanted to take into account whether people think that other people's attendance influences their experience. Therefore, they aimed to evaluate how much a person pays attention to others and how much they believe that participating in the group of the audience and sharing the experience bonds them. According to the theory of social identity, the more we identify with a group, the more attention we will pay to its members and the more we will be influenced by them (Tajfel & Turner, 1979). Social identity refers to those aspects of an individual's self-image that arise from the perceived membership in social groups and categories (e.g., gender, nationality, or fandom), as well as the value and emotional significance associated with this feeling of belonging (Tajfel, 1978). Classifying individuals and groups into distinct categories, such as 'us' (the in-group) and 'them' (the out-group), helps individuals to understand social structures and establish their social identity (Tajfel & Turner, 1979).

To measure how much individuals identify with their in-group of other audience members, the authors employed the In-Group Identification Measure (Leach et al., 2008). This measure includes two general dimensions: Self-Investment and Self-Definition, each consisting of several sub-scales. Self-Investment consists of Solidarity (based on the idea that people who identify most strongly with a group are also the ones most likely to feel psychologically bonded with its members; Lewin, 1948); Satisfaction (the positive feelings about the group membership; Tajfel, 1981; Tajfel & Turner, 1979); and Centrality (how important a person perceives their membership in a group to be for their own identity; J. C. Turner et al., 1994). Self-Definition consists of the sub-scales Individual Self-Stereotyping (the level of a person's

identification with a group, including the perceived similarity to the group's prototypical member; Tajfel & Turner, 1979; J. R. Turner, 1993), and In-Group Homogeneity (the perceived similarity between members of a group; Doosje et al., 1995).

After a pilot study and exploratory and confirmatory factor analyses of the data of a follow-up experiment, the authors were able to reduce the originally 65 items to 17 items. The factor analyses revealed five dimensions of social concert experience: Depth of Processing, Attention, Solidarity, Satisfaction, and Self-Definition. Depth of Processing captures the depth of information processing and the ability to recall the audience visually and to remember what the audience looked like. Attention describes one's attention paid to other members of the audience. Solidarity encompasses a felt bond and solidarity with, as well as commitment to, the other audience members. Satisfaction refers to the extent to which an individual is glad to be part of the audience and feels good about this. Finally, the dimension of Self-Definition describes a feeling of being similar to the other audience members or having a lot in common with them, and an internal homogeneity of the group of audience members.

In summary, the theories and concepts presented thus far suggest that attending a concert together can have a positive impact on the social relationships both between audience members as well as between audience members and performers, fostering pro-group feelings like social connection and liking. The Social Experience of a Concert Scale (O'Neill & Egermann, 2022) provides a more nuanced framework, comprising five dimensions of the social concert experience. The following section examines the concept of social connection in more detail, as it is often referenced and has been commonly investigated in the context of concerts, making it comparable across studies. Within the dimensions of the SECS, social connection aligns most closely with Solidarity, which is measured by three items: "I felt a bond with the audience", "I felt solidarity with the audience", and "I felt committed to the audience".

Social Connection

A review by Baek et al. (2025) states that in the context of a rapid growth of research on social connection in psychology, the term 'social connection' became a "catch all term". The authors provide an overview of four different conceptualisations of social connection: 1) the subjective sense of belonging or relatedness to others; 2) the components and structure of an individual's social network (e.g., the number of people with whom a person is linked or has a relationship with); 3) interpersonal synchrony, i.e. temporal interdependence between two or more people, including behavioural (e.g., synchronous movements) and physiological (e.g., correlated neural responses) alignment; and finally 4) connection behaviour, which refers to observable ways in which people engage or disengage with others socially. In their review, the authors considered works from psychology and related disciplines that used the

term ‘social connection’, as well as its derivatives, such as ‘social connectedness’ and ‘socially connected’. They excluded work that does not explicitly use the term ‘social connection’.

The first conceptualisation – framing social connection as a subjective sense of belonging – best captures the social dynamics described above that can occur during concerts. Baek et al. (2025) state that “any measure that captures individuals’ subjective perceptions of how connected individuals feel to other people (or to social groups, communities or entities) falls under this characterization” (pp. 507–508), distinguishing this conceptualisation from structural or behavioural indicators. In concert settings, it is not the visibility of direct interaction or the size of social networks that defines the quality of connection with fellow audience members or performers, but the sense of connection. Connection behaviour may indicate, accompany or induce this feeling of connectedness. This thesis therefore focusses on the subjective dimension of connection, as it most accurately reflects the phenomena and dynamics described in earlier sections as part of social audience experience.

Notably, Baek et al. (2025) also identify connection synchrony – including phenomena such as synchronous movement entrainment – as a third conceptualisation of social connection. Synchronous movement to the music has already been explored in section 2.2 as a key behavioural phenomenon of the reception of music and concert experience. The relationship between these two conceptualisations – joint movement and a subjective connection perception – will be outlined in section 2.4.

The subjective perception of being connected to others can be described more generally as a fundamental human need, the “need to belong” (Allen et al., 2021; Allen et al., 2022; Baumeister & Leary, 1995). It has been suggested that this need to belong has its roots in evolutionary selection: Throughout evolutionary history, humans have been heavily dependent on others in order to increase their chances of survival. Individuals who were better at forming social relationships were more likely to survive and reproduce (Karremans & Finkenauer, 2023). Further, social interaction and social connectedness make us feel good (Berscheid & Reis, 1998; Diener, 1984), whereas being alone or lacking social contact and connectedness can lead to feelings of loneliness and depression (Cacioppo et al., 2006).

The emergence of social connection is a complex and multifaceted phenomenon. Overviews of social psychology usually do not cover or explain concepts such as ‘social connection’ (e.g., Baumeister & Finkel, 2010; Hogg & Vaughan, 2021; Reiss et al., 2023) and the review by Baek et al. (2025) does not address the emergence of social connection, either. Research on interpersonal attraction and the development of close relationships suggests that social connection can develop through mechanisms that foster liking between individuals. In particular, proximity, familiarity, and similarity have been identified as key factors increasing the likelihood of positive interactions and relationship formation (Hogg & Vaughan, 2021). They can provide further insights into how social connection arises.

Generally, simply being in the same physical space as another person increases the likelihood of liking them (Buunk & Dijkstra, 2008). The key role of physical proximity or propinquity in fostering friendships or social closeness was initially shown in a study by Festinger et al. (1950). They found that students living in the same building of a housing complex were over ten times more likely to form friendships than those residing in different buildings; moreover, living on the same floor increased the likelihood of friendship. For students living on the same floor, students were more likely to become friends with neighbours than with those living further down the hallway.

Physical proximity increases the chances of random encounters, which can in turn serve as a foundation for the development of social relationships. Frequent exposure to others also leads to increased familiarity, which can increase sympathy for others. This can be explained with the mere-exposure effect, first proposed by Zajonc (1968). It refers to the psychological phenomenon that increased familiarity through repeated exposure to an originally neutral stimulus leads to more positive attitudes toward it. A study by Saegert et al. (1973) demonstrated that participants' liking for another increased with the frequency of their encounters.

Finally, physical proximity and frequent interaction not only lead to familiarity, but also give people the opportunity to discover things they have in common (Karremans & Finkenauer, 2023). This brings us back to the effects of similarity, which were described above as having a positive impact on social concert experience. Taking into account the theories and perspectives presented so far, we may conclude that attending a concert is a social event that leads to a social experience and specifically social connection. Sharing the same experience and attentional focus can lead to a unified mental state, a feeling of being part of a group, sharing commonalities and similarities, which can in turn lead to pro-group outcomes like solidarity, liking, and a feeling of connection, both between audience members and between the audience and the performers.

The next section examines how the social experience of a concert can be measured, with particular emphasis on social connection, which has already been explored in various studies.

2.3.2 Measuring Social Experience of a Concert

Section 2.3.1 already introduced the Social Experience of a Concert Scale by O'Neill and Egermann (2022) as a validated measurement instrument for social experience of a concert. The questionnaire consists of 17 statements rated by participants on 5-point scales, measuring the five dimensions Satisfaction, Attention, Self-Definition, Solidarity, and Depth of Processing. Although the SECS was originally developed in the context of Western art music concerts, it may also be applicable to other concert contexts. Section 5.1 of this thesis describes the use of the questionnaire in the context of big band concerts .

Beyond the general social experience of a concert, numerous studies have more specifically investigated constructs that can mostly be categorised under the term 'social connection'. Baek et al. (2025) state in their review article that the measures of subjective social connection differ considerably and that they often vary in terms of timescale (e.g., momentarily, over a longer time span, or as a consistent feeling) and the target (a specific person versus connection in a broader sense with people in general). It should be noted that there is a general lack of standardised terminology and conceptual consistency across these studies in the context of concerts. Terms such as "social connectedness", "social connection", "social closeness", and "social bonding" are often used without clear operational definitions, and the distinctions between them are frequently unclear or absent. Consequently, these concepts are often used interchangeably, which complicates cross-study comparisons and theoretical integration. For example, there are studies from the field of concert research that will be reviewed further below which focus on "social connectedness" (Onderdijk et al., 2021), "social connection" (Swarbrick et al., 2021), and "connectedness" (Swarbrick & Vuoskoski, 2023), without providing a working definition of said terms. For the sake of transparency, the following review will retain the original terminology used in each study.

A study by A. S. Brown and Novak (2007) uses the term "social bonding" to assess the intrinsic aspects of a live performance. They refer to four different aspects of social bonding: 1) "Feeling a sense of belonging or connectedness with the rest of the audience", 2) "Celebrating or sustaining your own cultural heritage", 3) "Being exposed to cultures outside of your life experience", and 4) "Gaining new insight on human relations or social issues" (p. 16). The authors further emphasise that the majority of social bonding linked to attending live events takes place outside the performance itself, such as having dinner beforehand or meeting for a drink afterwards (A. S. Brown & Novak, 2007). Based on the four mentioned aspects, they use an index of four items. The one that refers to the audience is: "To what extent did you feel a sense of belonging or connectedness with the rest of the audience?"

Although the approach by Tarr et al. (2016) was originally applied in a silent disco study, it is easily transferable to a concert context and represents a broad and comprehensive framework to assess the relationship between audience members. To investigate the social relationship between participants, they used a combined "social closeness index" comprising scales that had previously been employed in other studies. This index consists of the mean score of several items with regard to the other participants: a rating of the felt connection ("How connected do you feel to the other participants?"; adapted from Wiltermuth & Heath, 2009), likeability ("How likeable were the other participants?"; adapted from Hove & Risen, 2009), similarity in personality ("To what extent do you feel similar in personality to the other participants?"; adapted from Valdesolo & Desteno, 2011), and an adapted version of the Inclusion of Other in the

Self (IOS) Scale by Aron et al. (1992). The IOS Scale consists of seven pairs of circles that overlap to varying degrees, representing the self and the other, with the degree of overlap of oneself with somebody else indicating the perceived closeness in the relationship, i.e. a perceived sense of being interconnected with another (Aron et al., 1992).

For measuring "social connection" in the context of livestreamed concerts, Swarbrick et al. (2021) developed a multidimensional measure comprising three components: Feelings, Social Presence, and Behaviours, assessed through a 10-item scale. The Feelings dimension captured participants' sense of connection ("How connected did you feel to the performer(s) / audience?"), as well as their perception of shared emotional states. The perceived Social Presence dimension was operationalised using two items adapted from the Social Presence subscale of the Multimodal Presence Scale (Makransky et al., 2017), measuring participants' subjective feeling of being in the company of others and their sense that others were aware of their presence. The Behaviors dimension included items assessing participants' active involvement in concert-related interactions, such as reading, commenting on, sharing, or discussing content related to the event. However, despite its multidimensionality, the scale is rarely reflected upon throughout the publication, and so far, the authors have not reused it in subsequent studies.

The study by Onderdijk et al. (2021) uses fewer rating scales to measure the concept of "social connection", "connectedness", and "social connectedness" (all three terms are used throughout the study) between the audience members, and between the audience and the musicians (from the audience perspective). Like Tarr et al. (2016), they measure connection explicitly ("To what extent did you feel connected with the artist(s) / (virtual) audience during the concert") on a rating scale and with an adapted version of the IOS Scale. Swarbrick and Vuoskoski (2023) as well measured "connectedness" with simple rating scales asking for the connectedness felt with the audience and the performers.

Summarising the measurement approaches and items presented here, it becomes evident that despite variations in terminology, they mostly assess the same underlying construct: social connection to or the perceived sense of closeness with fellow audience members or performers – mostly through explicit self-report items or via an adapted version of the IOS Scale (Aron et al., 1992). In response to the criticism by Baek et al. (2025) that measurements often have different objectives and timescales, it can be stated that, in this particular case, they are relatively consistent. The social closeness index by Tarr et al. (2016) additionally includes the pro-group outcomes likeability and similarity in personality.

Having outlined the methodological approaches to measuring the social experience of a concert, the next section looks at empirical studies that have examined this concept in practice.

2.3.3 Variables Influencing Social Experience at Concerts

First, this section presents a review of empirical research examining the variables that influence the audience's social relationship to the musicians. It concentrates specifically on the social connection between concertgoers and performers, because this is the only dimension of the social concert experience that has been systematically examined in previous audience research. Subsequently, research on the social concert experience and social connection among audience members will be examined. With regard to social connection measures, the terminology is generally used as it appears in the studies.

Variables Influencing Social Connection Between Audience Members and Musicians at Concerts

In a typical concert setting, there is usually a physical distance separating the audience from the musicians, which does not initially suggest a strong connection between the two. Nevertheless, research has demonstrated that there is a measurable link between audience members and musicians, which varies due to several influencing variables.

A number of studies have compared the social connection of audiences with performing musicians in different streaming concert formats. As this thesis does not seek to compare different forms of media mediation of concerts, the following section focusses on findings concerning social connection, independent of the effects of media mediation. It should be mentioned, however, that studies generally found positive effects of simultaneity, (social) presence or the 'sense of being there' on the audience's feeling of social connection with the artists (Onderdijk et al., 2021; Swarbrick & Vuoskoski, 2023; Swarbrick et al., 2021).

The study by Onderdijk et al. (2021) compared three livestreamed concerts of different genres (classical music for solo piano, contemporary experimental improvisation on bass clarinet, violin, and percussion, as well as Arabic and Western music on violin and accordion). They found that the amount of time participants spent watching the concert predicted social connectedness with the artists. The authors explain this finding by an increased understanding of the music and the musicians' role as a result of the viewing time. The authors also found that empathic concern was a predictor of social connectedness. They attribute this to the fact that increased empathy is linked to increased parasocial interactions (Horton & Wohl, 1956). Further, concentration fostered the connectedness with the musicians. The authors explain this finding by suggesting that participants may have experienced stronger feelings of presence through concentration. Knowing people in the audience also affected how connected participants felt to the musicians. This can be explained by the fact that participants may already have felt connected to the people they knew in the audience, which could have strengthened their connection to the musicians. Finally, participants reported feeling more connected to the artist when the final song performed was their preferred choice of two op-

tions, even if they had not had the opportunity to vote for it (in one condition, half of the participants were allowed to vote for their preferred song to be played). The authors interpret this finding cautiously, suggesting that participants may evaluate the musicians more favourably due to their assumed common preference of the same song.

The study by Swarbrick et al. (2021) compared a great number of different livestreamed concerts from different musical genres and countries. The authors did not distinguish between social connection with the musicians and connection with the other audience members in their analysis. Similar to findings by Onderdijk et al. (2021), this study found that general social connection was predicted by empathic concern. In terms of musical styles, dance and electronic music genres evoked more social connection than pop or classical music. As dance music typically induces more movement in listeners, the authors argue that moving with the performers may have produced more connectedness. Although participant or musician movement was not assessed, they interpret the enhanced connection in terms of potential motor entrainment with the music or performers' movements. Simple observation of the performers' movements may also have activated kinaesthetic empathic processes, further fostering social connectedness. Counter-intuitively, the study also found that social connectedness is not related to the real level of interaction between performers and audience.

Swarbrick and Vuoskoski (2023) compared a live concert of a string quartet with the live streamed version watched by participants at home. The amount of time that each participant spent moving (quantity of motion) and the alignment of stilling with the music were measured using smartphone accelerometers via a dedicated application. Overall, the audience members reported more connectedness to the musicians than to the audience. Predictors of connectedness to the musicians were trait empathy and, perhaps unsurprisingly, being a fan or admirer of the string quartet. Because connectedness was measured after each piece, the authors were able to determine that folk pieces generally evoked stronger feelings of connectedness compared to classical pieces. The authors argue that because the folk pieces elicited more movement in the audience, this collective rhythmic movement could have enhanced connectedness with the musicians, who also stomped their feet along to the beat.

In summary, empathy, concentration, the amount of time spent watching, familiarity with other audience members, and liking the musicians appear to influence the audience's sense of connection with the musicians, rather than the musicians' interaction with the audience. Results of two studies reported here will be revisited in the subsequent part, which focusses on social audience experience and social connection among audience members.

Variables Influencing Social Experience of a Concert and Social Connection Among Audience Members

The study by O'Neill and Egermann (2022) presenting the Social Experience of a Concert Scale found that the audience's social experience of the concert was related to overall concert enjoyment, but not to the emotional response to the music. Further, overall social concert experience was not significantly predicted by attending the concert with someone else. The authors, however, identified predictors of single social experience factors: attending the concert with someone else was negatively associated with a feeling of solidarity with the other audience members and attention to the other audience members. They argue that the accompanying persons could have distracted the participants from the other people in the audience. Moreover, older participants showed greater solidarity with the other audience members and a higher level of depth of processing, as reflected in their ability to visually recall and remember the appearance of the audience, compared to younger participants. Aside from that, they found that higher levels of musical training were positively associated with greater depth of processing.

A qualitative study in the context of a chamber music festival by Pitts (2005) showed that being able to see and respond to the reactions of others in the audience can enrich the social aspect of the concert experience.

Bennett (2014) found that texting or tweeting during a live concert of the U.S. singer-songwriter Tori Amos can both strengthen and weaken the social experience: While it fosters a sense of group experience, supports fans who cannot attend by allowing them to feel involved, and helps preserve personal memories, it may also interrupt the immersive flow of the concert and reduce connection with those physically present.

Concerning predictors of audience connectedness, Onderdijk et al. (2021) identified social presence, shared agency, and physical presence in various livestreamed concert settings. Their findings also suggest that older participants tended to feel less connected to fellow audience members, potentially due to lower familiarity with virtual platforms.

As already mentioned in the previous section, Swarbrick and Vuoskoski (2023) found that participants generally reported stronger feelings of connectedness with the performers than with other audience members, which may be attributed to heightened attention directed towards the musicians. As was the case for the feeling of connectedness with the musicians, the authors further found that participants reported the highest feeling of connectedness with the audience for the folk tunes compared to the classical pieces. In this case, they also argue that shared rhythmic movement, such as stomping in time with the beat, may have contributed to the heightened sense of connection. They also report a positive relationship between the motion of people sitting next to a participant in the audience and connectedness during the folk pieces of a string quartet performance. Conversely, they observed a negative relation-

ship during the classical music pieces. They explain this finding in terms of the behaviour of the participants' neighbours within the cultural norms of classical concerts (moving to the danceable folk pieces and remaining still during classical pieces). Moreover, the authors report on the frequency with which the audience became still, reducing their motion in line with quiet or meaningful musical moments. A higher frequency of stilling was related to greater connectedness with the other audience members. Given that their study was correlational and not causational, the authors speculate that there are several explanations for why connectedness and stilling could be related. They suggest that this perceived connectedness may have led to the stilling behaviour, as listeners who felt more connected to others tended to align with the cultural norms of a classical concert by showing greater restraint during quiet passages. However, they argue that it could also be the opposite in that the synchronous stilling with other people in the audience could have been perceived as a coordinated and entrained action and thus have led to a stronger feeling of community. The authors suggest that the synchronous moments of stillness were experienced as shared attention, which could also explain the relationship between stilling and connectedness. They further found that fans of the string quartet also showed higher connectedness to the other audience members, as they probably identified more with fellow fans.

To summarise, the concert studies referenced here mainly found effects of physical or social presence, shared attention, and fandom on the social connection among audience members. Movement or stilling of the audience members next to the participants within a cultural norm was also associated with the individual's connection to the other audience members.

This section has demonstrated that live concerts are significant social contexts that actively shape interpersonal experiences, including feelings of connection. Drawing on foundational concepts from social psychology, the notion of social connection was identified as a central and frequently reported phenomenon within social concert experience. However, it remains inconsistently defined and operationalised across existing research. A subsequent literature review synthesised findings from studies investigating the social experience of live concerts and social connection. While some studies suggest that joint movement contributed to heightened social connection, they did not directly measure synchrony or movement entrainment. Nevertheless, there is compelling theoretical and empirical rationale to assume a meaningful relationship between synchronous movement and social connection as well as further pro-group variables such as similarity, likeability, and trust. The following section therefore aims to explore this interplay.

2.4 Relationship Between Joint Movement Entrainment and Pro-Group Thinking

The review paper by Baek et al. (2025) was introduced in section 2.3.1 as a framework for conceptualisations of social connection. Besides the subjective perception of belonging or relating to others, which was reviewed in the previous section, the authors conceptualise social connection as "synchrony between individuals in a dyad or group" (p. 511). They further state that existing literature established interpersonal synchrony as the physiological basis for social connection (Wheatley et al., 2012) and as a "direct social bonding agent" (Launay et al., 2016).

At this point, it is important to acknowledge that within the context of live concerts, the concept of social connection is frequently studied and has been emphasised and investigated as a central component of the social concert experience. In the context of studies investigating effects of joint movement, however, the concept of 'social bonding' is used more frequently. Bamford (2022) conceptualises social bonding by measures of liking, connection, and IOS. In a meta-analysis by Mogan et al. (2017), the authors state that, in the literature, perceived social bonding has been conceptualised using measures including "trust, entitativity, interconnectedness, closeness, attraction, similarity, liking, affiliation, rapport, social cohesion, self-construal, feelings of belonging, identification, personal value and voice to the group, prosocial intentions, perceived cooperation, perceived competence of the partner, and perceived physical formidability of another" (p. 16). Savage et al. (2021) also use social bonding "as an umbrella term [...] to encompass a variety of social phenomena including social preferences, coalition formation, identity fusion, situational prosociality, and other phenomena that bring individuals together" (p. 2). In summary, social bonding can be considered as a superordinate concept that encompasses social connection and further pro-group outcomes within the context of social concert experience. Additionally, in the context of research on joint movement, the adjective "prosocial" is widely used to describe the effects of synchrony, mainly for behaviour or intended behaviour (actions that benefit others), but also more generally for effects such as social connection (e.g., Rennung & Göritz, 2016). However, L. Cross et al. (2019) argue that the term "pro-group", rather than "prosocial", is more appropriate for describing behaviours or feelings towards others following synchronous movement. This terminology is considered to be more precise, as the observed effects predominantly concern individuals who have moved together, i.e., indicating an in-group effect (Tajfel et al., 1971). Furthermore, the term "prosocial" may vary in meaning depending on contextual factors and interpretative perspectives, as it broadly encompasses behaviours or attitudes that benefit others in general, regardless of group boundaries or relational proximity. In contrast, the term "pro-group" refers specifically to affiliative behaviours and thoughts

directed toward a clearly defined group, such as individuals who have engaged in synchronous movement together. Therefore, the authors claim to use the terms pro-group thinking and pro-group behaviour to describe effects of interpersonal entrainment. With reference to this conceptual integration, pro-group thinking is adopted here as an overarching framework to describe social bonding outcomes of joint movement such as social connection, trust, likeability, and similarity.

The following section builds on this framework and summarises empirical findings on the relationship between joint movement and pro-group thinking outcomes, including explanatory approaches that engage with the underlying mechanisms of this association. However, when different studies are reported, the original terminology of the pro-group thinking outcomes is retained to ensure comparability.

2.4.1 Theoretical and Empirical Foundations

Several meta-analyses consistently found a small positive effect of synchronous movement on pro-group thinking outcomes in adults (Mogan et al., 2017; Rennung & Göritz, 2016; Vicaria & Dickens, 2016). The studies summarised in these publications include, among others, effects of finger tapping, moving cups, rowing or walking together, or rocking in a rocking chair. All of the above were mainly investigated in controlled laboratory settings. A comparable effect was also found for children (e.g., Rabinowitch & Meltzoff, 2017).

In their meta-analysis, Mogan et al. (2017) differentiate between four dimensions of response to assess the effects of synchrony: 1) prosocial behaviour, 2) perceived social bonding, 3) social cognition, and 4) positive affect. Prosocial behaviour refers to actions that benefit others, such as cooperation, helping, or sharing. As mentioned above, perceived social bonding captures among others the subjective sense of social connection, trust, likeability, and similarity. Social cognition encompasses cognitive processes that help individuals to interpret social information, such as attention, empathy, and understanding of others' intention. Finally, positive affect is typically measured through mood scales and self-reports of life satisfaction, happiness, and self-esteem.

Dealing with mechanisms that have evolved at early stages of human evolution, Tarr et al. (2014) propose that endorphin release, primarily associated with social grooming across primate species, is also facilitated when humans move and synchronise with each other (Dunbar, 2010). Durkheim (1995) suggests that collective activities in group ritual settings generally cause collective effervescence, a shared feeling of unitedness, and high positive emotional arousal. This could also be applied to concert settings.

Furthermore, having a shared intention to achieve a common goal can enhance the pro-group effect of synchrony (Reddish et al., 2013). In some concert cultures, moving in syn-

chrony to the music is an integral and important part of participation (e.g., Merriam, 1964). Therefore, at a concert, moving together to the music could be considered a shared goal.

Positive effects of synchrony on pro-group thinking have also been explained by a merging of the concept or sense of the self and the other (e.g., Rennung & Göritz, 2016; Tarr et al., 2014). This temporary blur of the sense of "self" and "other" (Overy & Molnar-Szakacs, 2009) is driven by shared sensorimotor activity: When one perceives and performs the same actions as another person, overlapping neural motor networks are activated (e.g., Fadiga et al., 1995; Overy & Molnar-Szakacs, 2009). Additionally, Tarr et al. (2014) argue that both synchronous movement and self-other merging engage reward systems in the brain that can also positively affect social bonding.

This mechanism of self-other merging through shared sensorimotor activity is particularly evident in musical contexts, in which perception and action are closely linked. According to the Shared Affective Motion Experience (SAME) model by Overy and Molnar-Szakacs (2009), music is perceived not only as sound, but also as a sequence of expressive motor actions performed by the musicians. Listeners simulate these actions internally, creating shared sensorimotor and emotional engagement with the performers. This embodied resonance could foster empathy and promote feelings of social connection, even during passive listening. In addition, Valdesolo and Desteno (2011) found that synchrony can also result in the perception of increased similarity with the other. This can be explained through a reduced processing load through synchrony, which leads to a decrease of the perceived self-other differences (Wheatley et al., 2012). Bamford (2022) further suggests that reduced processing load is inherently rewarding and therefore leads to a positive feeling towards the other.

To outline the possible relationships among different theories, Bamford (2022) proposes a model suggesting that synchrony increases the perception of similarity with others, which in turn increases attention, making it easier to synchronise. Achieving synchrony can also be interpreted as the achievement of a shared goal, which can be rewarding and may motivate further synchrony or collaboration. Social or cultural contexts can also influence behavioural expectations regarding synchrony. As the interaction and synchrony continue, the processing load for participants should decrease; that is, individuals no longer need to monitor or adjust their actions consciously. This creates a sense of ease or fluency. Finally, this processing fluency is rewarding, generating positive emotional responses towards the interaction partner (Bamford, 2022).

There is evidence that these mechanisms are particularly potent in musical contexts and that music can enhance the positive effects of synchronous movement. Stupacher et al. (2017) suggest that synchronising to music may have a stronger effect on IOS and liking compared to synchronising to a metronome. Further, Stupacher et al. (2020) demonstrate that also the type of music can have an impact on IOS. When participants enjoyed the mu-

sic more in their study, IOS increased more in the synchrony condition compared to the asynchrony condition. When the music was more (culturally) familiar, IOS was higher independent of movement synchrony. However, both of these studies employed a video-based paradigm to simulate movement entrainment, using animated stick figures to represent synchronous and asynchronous movement patterns. As such, participants did not engage in actual physical movement but instead observed and responded to visual stimuli, limiting the ecological validity of the findings.

In a rocking-chair experiment, Demos et al. (2012) placed dyads side-by-side on rocking chairs while they listened to the same piece of music. Synchronisation with the music was positively correlated with participants' sense of feeling connected with their partner. By contrast, movement synchrony between partners showed no such relationship. The authors suggest that it may be due to the impression of sharing the same experience of synchronising to the music.

It can be argued that the effects of movement synchrony on pro-group thinking outcomes, as reported here from controlled experimental settings, are likely to be applicable to live concert contexts, in which audience members move in synchrony with the music. Given the shared rhythmic entrainment, these effects may not only emerge among audience members but also between the audience and the performers.

2.4.2 The Need for Further Research in the Context of Concerts

To my knowledge, there is currently no study that investigated the effects of joint movement entrainment on social audience experience or further pro-group thinking outcomes in an ecologically valid concert setting. Three studies, however, have investigated these effects and related phenomena in comparable, more controlled contexts using silent disco paradigms. They are concrete evidence that these effects can also occur in ecologically valid concert contexts and will be briefly presented in the following.

In a silent disco scenario in which two groups dance in a room, each listening to different music, Woolhouse et al. (2016) found that participants' memory was better for members of their own group than for members of the other group. The authors hypothesise that this effect arose from a greater focus of attention on the synchronous dancers in participants' own group than on the non-synchronous dancers in the other group. Attention can be seen as a prerequisite for social connection and pro-group thinking. However, as both groups listened to completely different music, it is also possible that the difference is due to the different affective qualities of the music.

Tarr et al. (2016) examined how different levels of movement synchrony affect social closeness (including IOS, felt connectedness, likeability, and personality similarity). Participants

danced either in full synchrony (same music and same instructed movements), partial synchrony (same music and different instructed movements), or complete asynchrony (different music and different instructed movements). Those in the full synchrony condition reported greater social closeness than those in the partial synchrony condition. Interestingly, no difference was found between the full synchrony and asynchrony conditions. It is likely that in the partial synchrony condition, the mismatched coordination drew attention to failed alignment, leading to less social closeness compared to the full synchrony condition. However, in the asynchrony condition, when coordination was entirely absent, participants may have disengaged from others and focused on themselves to avoid the negative effects of perceived failure, explaining that there was no difference in terms of social closeness between the full synchrony and the asynchrony condition. The study suggests that the quality and subjective perception of synchrony may play a key role in fostering social connection.

Bamford et al. (2023) also used a silent disco scenario to investigate freestyle dancing of dyads. To introduce different levels of movement synchrony, both participants listened to the same music track in absolute synchrony in one condition, in another condition the track one participant listened to had a slightly different tempo (tempo-shifted), in the third condition one participant listened to a track with a delay of a quarter of a beat (phase-shifted). The authors found that participants rated their experience with their partner more positively when they danced to the synchronous music, and participants also looked towards each other more in the synchrony condition.

In addition, two studies reported in section 2.3.3 attributed increased social connection to audience movement (Swarbrick & Vuoskoski, 2023; Swarbrick et al., 2021). However, the synchrony of participants' movement frequency with the other participants or musicians was not assessed, and in one case only, the amount of movement and alignment of stilling with the music was measured. Therefore, this claim lacks empirical validation.

It can be concluded that, while the literature suggests a potential link between synchronous movement and the social concert experience, particularly in terms of pro-group thinking variables such as feelings of social connection, trust, likeability, and similarity, empirical evidence from ecologically valid contexts remains limited. This gap underscores the need for a systematic investigation, forming the basis for the research aims and objectives outlined in the following section.

3 Aims and Objectives

The literature reviewed in the previous section highlights key insights into movement entrainment and the social experience of concert audiences. Both phenomena are widely regarded as central to the live concert experience. Rhythmic movement in response to music reflects a fundamental aspect of human behaviour, while the social dimensions of concert attendance are considered as a defining characteristic of live performances. Empirical evidence from contexts other than live concerts – particularly laboratory settings – suggests a strong link between synchronised movement and pro-group outcomes such as social connection, perceived similarity, likeability, and trust. Given that synchronised movement to the music is a central feature of the audience experience in many concert contexts, it is highly plausible that similar dynamics occur in this naturalistic setting. Yet, despite this strong theoretical and contextual plausibility, the interplay between movement entrainment and social experience has not been systematically investigated within live concert environments. Instead, these two dimensions have largely been studied in isolation, leaving a critical gap in understanding how they relate in ecologically valid concert settings.

This thesis therefore aims to investigate audience movement entrainment, the social experience of concert attendees, and the relationship between the two, in ecologically valid concert settings. A particular focus is placed on the role of the concert format, specifically standing versus sitting, in shaping both movement entrainment and general as well as social concert experience. The thesis is based on three datasets collected at four live performances: Concert Dataset 1 (a rock concert), Concert Dataset 2 (two big band concerts), and Concert Dataset 3 (an indie-pop concert). These genres were selected due to their underlying sociocultural norms which encourage or even expect audience members to move in response to the music, making them ideal contexts for investigating movement entrainment in naturalistic settings. The three concert datasets are presented in two subsequent empirical chapters. Whereas chapter 4 focuses on movement entrainment, chapter 5 examines general and social audience experience, and connects the latter with movement entrainment:

1. Concert Dataset 1: Movement entrainment has so far usually been assessed using small sample sizes or in scenarios where participants' movements were restricted. Therefore, the aim of this study was to explore if audience movement entrainment – defined as

the extent to which people move to the beat of the music they hear at a concert – can be measured in an ecologically valid concert setting (presented in section 4.1).

2. Concert Dataset 2: The aim of this study was to examine factors influencing audience movement entrainment in an ecologically valid concert setting. To increase the natural variability of movement entrainment, an experimental condition was added: One concert was seated and the audience sat during the concert, the other concert was unseated and attendees had to stand (presented in section 4.2).

   Section 5.1 presents a reanalysis of Concert Dataset 2 from the perspective of general and social concert experience, examining the impact of the concert condition on social concert experience, as captured by the SECS (O'Neill & Egermann, 2022), and identifying additional contributing factors. Further, the influence of different concert formats on the overall concert experience – namely concert evaluation and affective state – is assessed.

3. Concert Dataset 3: This study investigates the relationship between audience movement entrainment and social audience experience as captured by several pro-group thinking variables. The effect of movement entrainment on social connection in particular is examined – both between audience and performers and among audience members –, alongside further contributing variables (presented in section 5.2).

4 Exploring Movement Entrainment in Ecologically Valid Concert Settings

This section focuses on the investigation of movement entrainment in ecologically valid concert environments. The first part, section 4.1, demonstrates the testing and validation of a method to assess movement entrainment of the audience, based on acceleration data collected from portable devices worn on the arm and torso. The second part, section 4.2, focusses on the factors predicting movement entrainment.[1]

4.1 Measuring Movement Entrainment

This section is based on Concert Dataset 1.

4.1.1 Aims

The aim of this study was to develop and test a suitable method for measuring movement entrainment in an ecologically valid concert setting. This study presents the measurement of naturalistic audience movement entrainment at a live standing concert. Unlike previous studies, the audience was free to move as they wished, without being constrained by the study design or measuring devices. This study thus makes an important contribution to research because it expands on studies from Western classical concerts (e.g., Seibert et al., 2019; Tschacher, Greenwood, Ramakrishnan et al., 2023) – in which movement is normally restricted by social conventions – and studies that measured movement from seated audiences (Swarbrick et al., 2019).

The study was conducted at an unseated rock concert, at which people could move around freely. The portable devices, attached to the arms and torsos of our participants in the audience, measured acceleration data. We defined movement entrainment as the extent to which people moved to the beat of the music they heard at the concert.

[1] The present chapter has been published with some adaptations and in a different format as Hochgesand and Egermann (2025) .

We were driven by the following research question:

Can movement entrainment be measured in an ecologically valid concert setting?

4.1.2 Methods

Participants were informed about the study procedure in advance and gave their written consent. The study was approved by the ethics committee of the DGM (the German Association for Music Psychology) and was performed in accordance with their guidelines and regulations. These also refer to the regulations of the DGPs (the German Psychological Society).

Participants

We collected data from 42 volunteers (female = 24, male = 17, other = 1; mean age: 26.2 years, *SD* = 9.8) recruited through email, social media, posters, and in person on arrival at the free concert, immediately before it started. Participants were mainly students (81%) and 69% stated in the questionnaire that they describe themselves as musicians. 64% of the participants came to the concert with someone else. At the end of the experiment, all participants received 10 Euro compensation in cash. We excluded one participant's data for the first eleven pieces and a second participant's data for the last 15 pieces because they were part of the organising committee for the student concert and helped with tasks such as selling drinks.

Stimuli

The experiment was conducted during a concert at the Music Institute of TU Dortmund University. The first part of the concert featured six solo pop songs, performed by a number of students. The second part featured four different rock bands, each performing three to four cover songs. The last part of the concert was a brass band playing 13 pieces, mostly cover versions of popular pieces from the pop genre (for the full set list with BPM values, see Table 4.1). The concert started at 7:15 PM and ended at around 10 PM on a Wednesday evening. It took place in a room in the basement of a university building which is provided with a stage, sound system, and stage lights. There were in total around 100 people attending the concert, drinks were provided and everyone, including the participants, was allowed to enter and leave the concert hall at any time. Two photographs of the concert are presented in Figure 4.1.

Table 4.1: Set list and BPM values of the pieces performed at the rock concert.

Piece No.	Performer	Piece title	Covered piece by	BPM value
1	Solo 1	Just Another Day	Lady Gaga	82
2	Solo 2	Girl With One Eye	Florence + the Machine	82
3	Solo 3	What a Wonderful World	Louis Armstrong	82
4	Solo 4	Your Song	Elton John	62
5	Solo 5	Strange	Celeste	68
6	Solo 6	New York	Paloma Faith	86
7	Band 1	Smells Like Teen Spirit	Nirvana	122
8		Emily	Adam Green	128
9		Wicked Game	Chris Isaak	108
10		Song 2	Blur	126
11		Song 2 *(Encore)*	Blur	128
12	Band 2	Highway to Hell	AC/DC	124
13		I Shot the Sheriff	Bob Marley	94
14		Learn to Fly	Foo Fighters	132
15		Highway to Hell *(Encore)*	AC/DC	126
16	Band 3	Boulevard of Broken Dreams	Green Day	92
17		Summer Wine	Lee Hazlewood & Nancy Sinatra	136
18		Thunderstorm	Self-written by guitarist Mascha	148
19		Boulevard of Broken Dreams *(Encore)*	Green Day	90
20	Band 4	Talkin' Bout a Revolution	Tracy Chapman	108
21		Creep	Radiohead	94
22		Free Fallin'	Tom Petty	94
23		Free Fallin' *(Encore)*	Tom Petty	94
24	Brass Band	*Ein Prosit der Gemütlichkeit* [a]	*Georg Kunoth*	*Strongly fluctuating tempi*

- continued on next page -

Table 4.1: Set list and BPM values of the pieces of Concert Dataset 1 – *continued from previous page*

Piece No.	Performer	Piece title	Covered piece by	BPM value
25		*Happy Music* [a]	*James Last*	*Strongly fluctuating tempi*
26		Hit Me With Your Best Shot	Pat Benatar	132
27		*Soon May the Wellerman Come* [a]	*Sea Shanty*	*Strongly fluctuating tempi*
28		Teenage Dirtbag	Wheatus	104
29		High Hopes	Panic! At the Disco	144
30		*Bella Ciao / Havana (Medley)* [a]	*trad. / Camila Cabello*	*Strongly fluctuating tempi*
31		Maxglaner Marsch	Robi Reiser	152
32		Feel It Still	Portugal. The Man	144
33		Drink doch eine met	Fred Hoock	69
34		Cordula Grün	Die Draufgänger	134
35		Interlude / Choral		60
36		Mama Laudaaa	Almklausi & Specktakel	134
37		Angels	Robbie Williams	70
38		Teenage Dirtbag	Wheatus	100

[a] Not used for analysis due to strongly fluctuating tempi.

Movement Data

Movement data for each participant were collected using the built-in accelerometer of two wearable devices (28 g and 31 g, each 65 × 32 × 12 mm). The Shimmer GSR + sensor was attached to the participants' non- dominant arm wrists and also measured skin conductance on the index finger and middle finger; the Shimmer ECG sensor was attached with a band around the participants' torso and also measured their electrocardiogram with two electrodes placed at the participants' chest (see Figure 4.2). Both devices measured acceleration in two ways: a 3-axis low noise accelerometer and a 3-axis wide range accelerometer. We decided to use both accelerometers because we expected a wide range of motion. By this, we could both measure large accelerations as well as smaller movements accurately.



Figure 4.1: Photographs of the rock concert.

Note. Top: One of the rock bands performing. Bottom: The audience during the concert.



Figure 4.2: A participant wearing the two devices on the arm and torso.

Data was recorded on the SD card in each device (Sampling rate GSR + device: 128 Hz; ECG device: 256 Hz). Please note that the data of skin conductance and the electrocardiogram are not included in this analysis. All movement data was recorded with a real-world timestamp from a Windows PC laptop that was running Shimmer's software ConsensysPro. To determine the exact time of the beginning of the concert and to be able to synchronise the acceleration data with the audio-visual recordings, we took additional recordings of the laptop screen to capture its real-world time with the surrounding sound from the concert hall.

Pre-Concert Questionnaire

Before the concert, we collected sociodemographic data of the participants, if they were students, and if they attended the concert alone or in company (the full questionnaire can be found in the appendix B.1).

Post-Concert Questionnaire

In the post-concert questionnaire, we asked for participants' concert experience and if they had the desire to move and dance on a 5-point scale (1 = *not at all*, 5 = *very much*; see appendix B.2).

Audio-Visual Recordings

The concert was recorded with two cameras, one facing the audience and one facing the performers on the stage throughout the duration of the concert.

Procedure

Figure 4.3 provides an overview of the experimental procedure and the data collection process. These apply to all datasets presented in this study. Participants were greeted at the entrance, received an information sheet about the experiment, and filled out the consent form. They then completed the pre-concert questionnaire at tables provided in the foyer of the venue. This took approximately ten minutes. To be able to assign the questionnaires to the movement data, we used anonymous IDs generated by the participants themselves. Then participants were fitted with the two devices. Participants were not restricted in their movement by the devices worn on their bodies. After the measuring devices were attached, the participants were allowed to move freely in the building. They were not given any further instructions, and they were not encouraged to behave or move in any particular way during the concert. After the concert, participants filled in the post-concert questionnaire. This took approximately ten minutes. After completing the questionnaire, the participants were thanked and received their compensation for the participation.

Participants were further allowed to leave the concert at any time they wanted and to finish the experiment before it ended. There were no more COVID restrictions in the summer of 2022, yet some people voluntarily wore masks during the event. After the experiment, participants were debriefed.

Data Analysis

Musical Feature Extraction. The tempi of the performed pieces at the concert were determined by two musically trained raters who listened to the recording of the concert and tapped along to the beat of each played piece using a metronome application. The mirtempo function of the MATLAB MIRtoolbox (Lartillot, 2010; Lartillot & Toiviainen, 2007) was used to confirm the tempo analysis. Due to very unclear and fluctuating tempi, we had to exclude four pieces from the analysis.

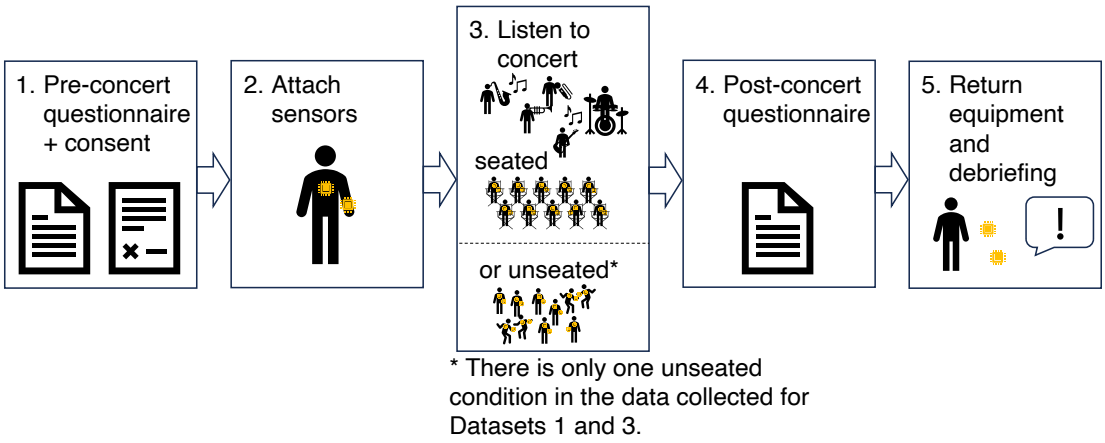


Figure 4.3: Overview of the experimental procedure and data collection process.

Note. The experimental procedure and data collection process presented in this figure are applicable to all the datasets presented in this thesis. There was only one unseated condition for Concert Dataset 1 and 3 as illustrated in step 3.

Movement Entrainment. We defined the degree of movement entrainment of each participant as the extent to which they moved their body with the frequency of the beat of each piece played at the concert.

For every participant, we had two datasets: One from the device at the arm and one from the device at the torso. Each dataset consisted of six acceleration values: three values for the three dimensions of the low noise accelerometer and three values for the three dimensions of the wide range accelerometer.

Using MATLAB (Mathworks, Version R2024b), we first conducted an interpolation, using the MATLAB function interp1. It is applied to each signal to assign the same number of temporal data points between two reference points. Then the full concert was segmented into the pieces of music.

Since the sensors measured acceleration on three axes, we calculated the square root of the sum of the squares of the three axes x, y and z as a measure of the overall magnitude of movement ($\sqrt{x^2 + y^2 + z^2}$). We used the mean of the low noise and the wide range accelerometer data, as the data was visually very similar, only slightly shifted up or down (see Figures A.1–A.3 in the appendix for raw data and step-by-step plots for the analysis). We then applied a fast Fourier transform, using the MATLAB function fft, to determine the extent to which the participants were moving at each frequency. Next, we extracted the power of the movement frequency within the range of the three metrical levels of the tempo of each piece: half the beat period (0.5 BPM; half-time), the standard beat level (BPM), and two times the beat period (2 BPM; double-time) within a tolerance range of ±5% (Burger et al., 2014).

Thus, we obtained six values of entrainment for each of the 34 pieces for every participant: 2 devices × 3 different metrical levels.[2]

4.1.3 Results

The estimated marginal means of movement entrainment across the different metrical levels measured at the arm and torso over the course of the concert for each piece are presented in Figure 4.4.

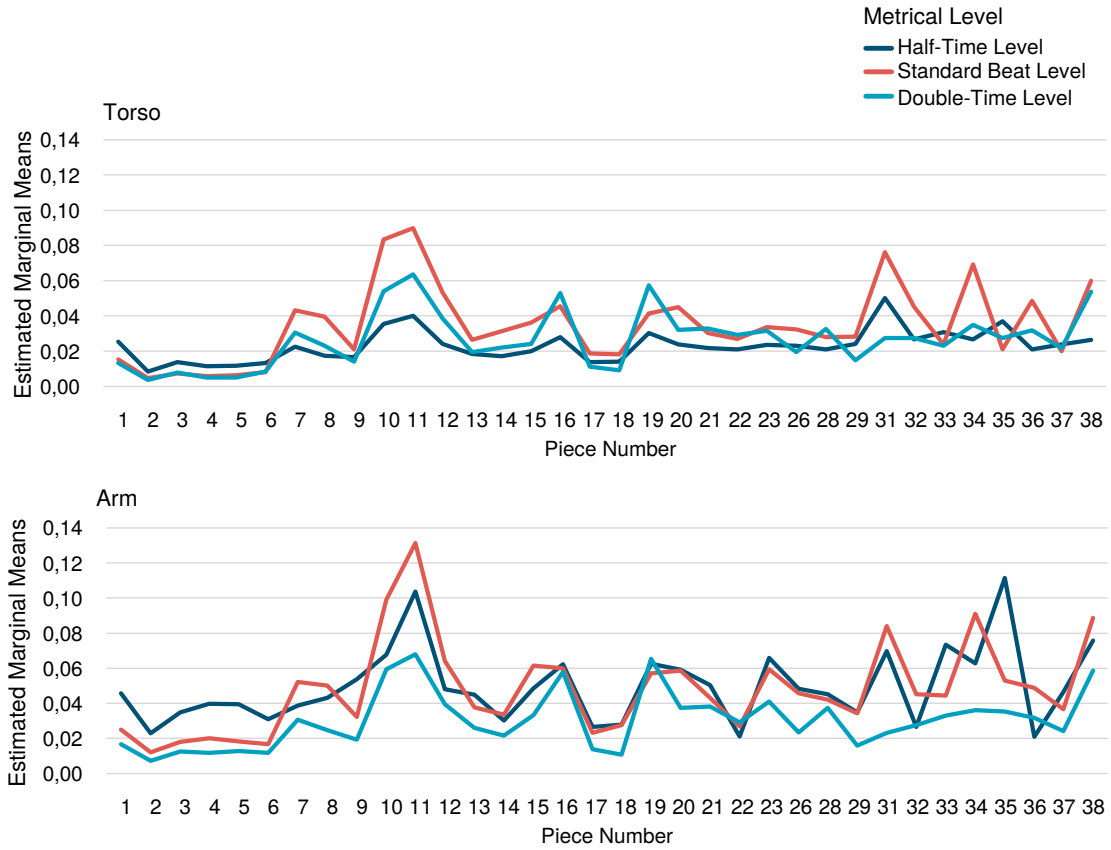


Figure 4.4: Estimated marginal means of movement entrainment.

Note. Data are distinguished by location of measurement (torso and arm) and by the three metrical levels half-time, standard beat, and double-time level.

To validate our measurement of movement entrainment, we compared the mean values of movement entrainment averaged over all pieces for the target BPM values to corresponding

[2] The MATLAB code for the analysis is available on the Open Science Framework repository: https://osf.io/rw9nh/files/osfstorage/683b2102b395195708539492.

values of movement entrainment calculated for control BPM values. We set the control BPM values at +10, +20 and +30 BPM above the target BPM values, and −10, −20 and −30 BPM below it. We analysed movement entrainment for each of these control BPM values and took the mean.

In this comparison, we differentiated between the two locations of measurement (arm and torso) and the three metrical levels (half-time level, standard beat level, double-time level), therefore we had 12 entrainment values for every participant (six each for the target BPM values and for the control BPM values). After Bonferroni corrections for six paired t-tests ($\alpha = 0.0083$) we found that participants' mean value of movement entrainment calculated for the target BPM values was consistently significantly higher compared to movement entrainment calculated for the control BPM values, $t(41) > 4.48$, $p < .001$ (Figure 4.5).

We further found that the mean value of movement entrainment during the concert correlated positively and significantly with participants' self-reported desire to move and dance during the concert from the post-concert questionnaire, $r(42) = .397$, $p = .009$. This also confirms the validity of our measurement of movement entrainment and demonstrates that the actual behaviour and the self-reported desire to dance during the concert are congruent.

4.1.4 Discussion

In this study, we measured significant movement entrainment to the music in an ecologically valid concert setting and demonstrated that it also was linked to self-reported desire to move and dance to the music.

In addition to studies that measured movement in laboratory or artificial settings (Solberg & Jensenius, 2017; Solberg & Jensenius, 2019; Tarr et al., 2016; Tarr et al., 2015), as well as ecologically valid settings in classical concerts (Czepiel et al., 2021; Tschacher, Greenwood, Ramakrishnan et al., 2023; Upham & Rosas, 2025), or a rock concert with restricted movement due to seating (Swarbrick et al., 2019), our study is the first to measure movement entrainment at a concert, at which participants were free to move, even dance. With the small devices, participants could behave as they would usually do at a concert. This expands the methods and possibilities of concert research and strongly implies that it is possible to conduct concert research in ecologically valid settings.

However, due to the accelerometer devices used in this study, we can only make a statement about peoples' movement to the music. As people were allowed to move freely in the room, we did not actually know where they were in the room and if they danced with each other. There are more accurate methods such as motion capture with multiple body markers (Solberg & Jensenius, 2017; Solberg & Jensenius, 2019) or only a few attached to the head (Cameron et al., 2022; Swarbrick et al., 2019) that would make it possible to also measure

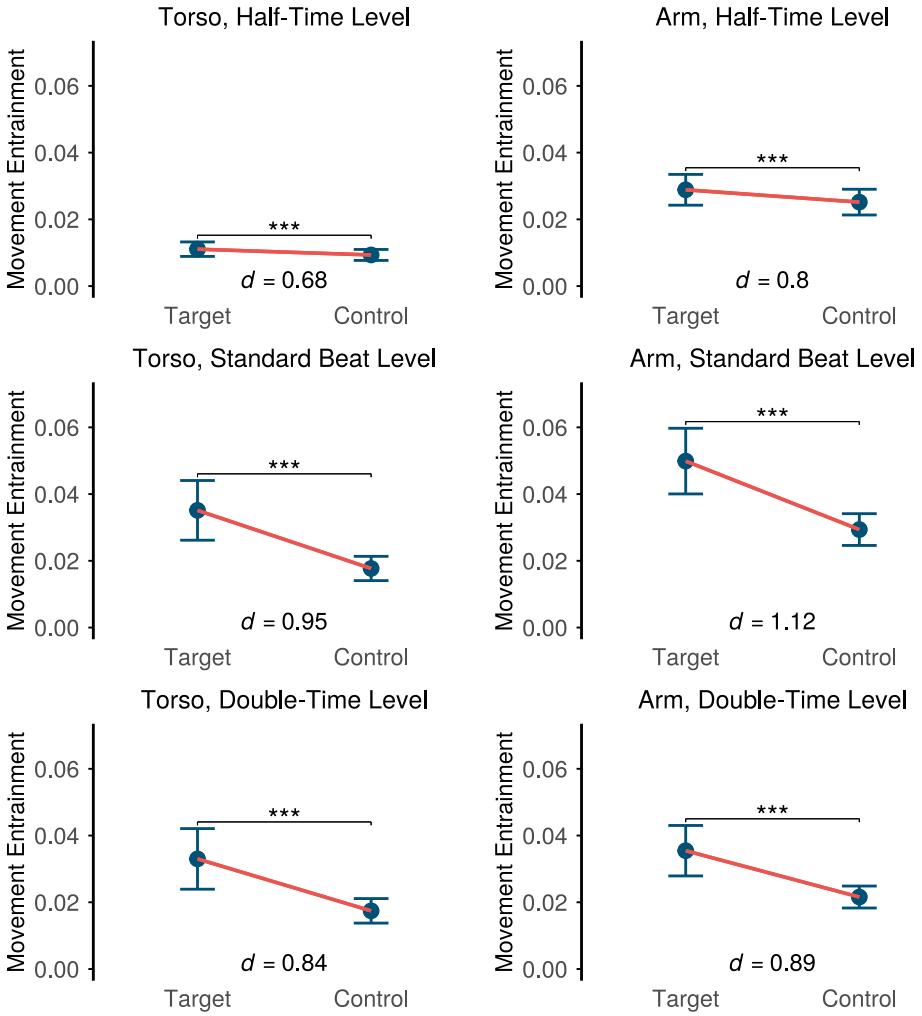


Figure 4.5: Mean values of movement entrainment calculated for the target BPM values for all pieces compared to values of movement entrainment calculated for control BPM values.

Note. Results for the two locations of measurement (arm and torso) and the three metrical levels (half-time level, standard beat level, and double-time level) are illustrated in the six plots. For the control values, movement entrainment was analysed for + and − 10, 20 and 30 BPM around the target value, then averaged. Error bars mark 95% confidence intervals. Effect sizes represent differences between movement entrainment calculated for target and control BPM values.

***$p < .001$.

participants' location in a room. Though, using motion capture in a concert hall with many people moving around requires a very sophisticated technical setup and possibly more restrictions for participants. Additionally, we could not control for what participants did during the concert while we collected their acceleration data. There were no instructions given on how to behave during the concert. This resulted in some participants holding bottles or mobile phones in their hands on the side to which the measuring device was attached. A trade-off exists between quality and accuracy of the data and the non-invasiveness of such recordings. The objective of this study was to focus solely on ecological validity, so we prioritised the unrestricted concert experience of our participants over the accuracy of our data. We argue that the possibility to measure a relatively large sample compensates for the fact that other methods of measurement would be more precise.

Finally, it should be noted that our self-report measure of 'desire to move and dance' does not necessarily equate to actual movement. Although we found a correlation between the desire to move and dance and measured movement entrainment, this finding should be revisited in future using another self-report measure, such as 'I moved to the music' (see section 5.2.3).

However, the present study represents a first attempt to explore movement entrainment in an ecologically valid live concert setting in which participants were also free to move and dance. This method is employed in the subsequent experiments to investigate various research questions.

4.2 Contributing Factors to Movement Entrainment

The following section is based on Concert Dataset 2.

4.2.1 Aims

After we have established a method for measuring movement entrainment in an ecologically valid concert setting, the aim of this study was to investigate influencing factors of movement entrainment.

To do so, we added an experimental condition in the following experiment to introduce more variability into movement entrainment. We measured audiences' movement entrainment at two similar big band concerts, with the only difference that one concert was seated, and the other concert was not seated and people had to stand. Before and after the concert, we assessed concert experience and personal factors via questionnaires.

Based on the description of a listener's reaction to music being the result of the music, the context, and the listener (Hargreaves, 2012; Scherer & Zentner, 2001), as presented in section 2.2.3, we hypothesised that we would observe varying degrees of movement entrain-

ment depending on *musical factors*, *situational factors*, and *personal factors*. As we measured movement entrainment with two devices on two different parts of the body, we additionally expected the influence of *factors of measurement*. We also included the metrical level here, as we expected people to move to different degrees to the different metrical levels of the music (the standard beat level or BPM, half-time level, and double-time level). Concerning musical factors, we limited our analysis to the effects of tempo as a characteristic musical feature (Fraisse, 1982; MacDougall & Moore, 2005; M. P. Murray et al., 1964; Van Noorden & Moelants, 1999) and included further musical features by considering the individual pieces in the analysis. As a situational factor we included the concert condition, as we expected to observe more movement entrainment in the standing condition compared to the seated condition. Finally, based on the literature, we assumed that the following personal factors would significantly affect audience movement entrainment: dance sophistication (Rose et al., 2022), positive affective state (Saarikallio et al., 2013), trait empathy (Bamford, 2022), liking the concert or the played music (Swarbrick & Vuoskoski, 2023) and the evaluation of experiencing the musicians live, and being familiar with the music (Ellamil et al., 2016).

4.2.2 Methods

Participants were informed about the study procedure in advance and gave their written consent. The study was approved by the ethics committee of the DGM (the German Association for Music Psychology) and was performed in accordance with their guidelines and regulations. These also refer to the regulations of the DGPs (the German Psychological Society).

Participants

A total of 70 participants attended one of the two concerts. Due to incomplete datasets we had to exclude one participant, resulting in a final sample of 69 participants. Of these, 28 participants (female = 13, male = 15; mean age: 30.1 years, SD = 10.4) attended Concert 1, and 41 participants (female = 21, male = 18, other = 1, 1 preferred not to say; mean age: 28.5, SD = 11.5) attended Concert 2. We used a short version with three items per subscale of the German version of the Goldsmiths Musical Sophistication Index (Gold-MSI; Müllensiefen et al., 2014; Schaal et al., 2014) to assess the participants' general musical sophistication (Concert 1: M = 15.1, SD = 5.3, extrapolated to the original 18 items as it is a sum score: falls between the 64th and 65th percentile of the percentile norms reported for the Gold-MSI normative sample; Concert 2: M = 14.5, SD = 5.4, corresponds to the 58th and 59th percentile). Most participants in both concerts indicated that their highest educational level was at least a university degree (Concert 1: 64.3%; Concert 2: 48.8%) or that they were still in vocational training, e.g., trainee, student, or apprentice (Concert 1: 25.0%; Concert 2: 34.1%). Most of the participants came to the concert with someone else (Concert 1: 82.1%; Con-



Figure 4.6: Photographs of the audience in the seated and standing conditions during the big band concerts.

Note. Top: The audience during the concert in the seated condition, Concert 1. Bottom: The audience during the concert in the standing condition, Concert 2.

cert 2: 73.2%). Participants were recruited via email, social media, posters, word-of-mouth, and street recruitment in front of the university canteen. The concert was free of charge and participants were offered a free drink after they checked in to participate in the study. Each participant listened to only one of the concerts, the one with the sitting condition or the one with the standing condition (photographs of the audience in the two conditions are presented in Figure 4.6). Participants did not know beforehand, which concert condition (sitting or standing) they were attending or that this was part of the experiment at all.



Figure 4.7: Photograph of the big band performing in one of the two concerts.

Stimuli

The experiment was conducted during two big band concerts on two Wednesday evenings in two consecutive weeks in the concert hall of TU Dortmund University. The band *Groove m.b.H.* consisted of 20 musicians including a singer and the band leader (a picture of the band taken at one of the two concerts is presented in Figure 4.7). At both concerts, the band played the same big band arrangements of seven pieces (for the set list with BPM values, see Table 4.2). The last piece was played two times: The first time, the singer explained the piece and taught the audience how to sing along; afterwards, the band started from the beginning and played the piece to the end. The band was instructed to play as similarly as possible on both evenings. The concert started at around 7:50 PM both times, with a delay of ca. 20 min. The reasons for the delay were different at each concert: In week one, the conductor of the band arrived late because of a traffic jam; in week two, many participants arrived

very close to the start of the concert and attaching the measuring devices took too long. The concerts lasted around 50 min each.

Table 4.2: Set list and BPM values of the pieces performed at the two big band concerts.

Piece No.	Piece title	Arranged by	BPM value (Concert 1)	BPM value (Concert 2)
1	In the Stone	Paul Murtha	112	108
2	Rainy Day in Vancouver	Chris Walden	86	82
3	Eleanor Rigby	Eric Richards	140	136
4	Too Close for Comfort [a]	Gordon Goodwin	148	156
5	Cancion de Cuna	Gabriel Peréz	116	108
6	Libertango	Paul Murtha	140	138
7	Mr & Mrs Adonis [a] ('rehearsal')	Mc Coy Mrubata, as recorded by "The Little Giants"	104	106
8	Mr & Mrs Adonis [a] (with audience sing along)	Mc Coy Mrubata, as recorded by "The Little Giants"	104	108

[a] With vocals.

Movement Data

The measurement and analysis of movement data was the same as described in section 4.1.2.

Pre-Concert Questionnaire

Before the concert, participants reported their preference for jazz music and several other musical genres. We used the genre categories from the Short Test of Music Preferences-Revised (STOMP-R; Rentfrow et al., 2011). To measure empathy, we used the German version (Paulus, 2009) of the Interpersonal Reactivity Index (Davis, 1980). To keep the questionnaire as short as possible, we used a short version which consists of two items for each of the dimensions Perspective Taking and Empathic Concern. The items were answered on a 5-point Likert scale (1 = *doesn't apply at all*, 5 = *applies completely*). To assess dance sophistication, we shortened the Dance Sophistication Index which measures both participatory (P) and observational (O) dance experience (Rose et al., 2022), and only used the item with the highest loading for each of the five factors Body Awareness (P1.4), Social Dancing (P2.3), Urge to Dance (P3.3), Dance Training (P4.3), and Observational Dance Experience (O1.2).

These items were answered on a 7-point scale (1 = *completely agree*, 7 = *completely disagree*). We further asked for sociodemographic data and if participants attended the concert alone or accompanied (for the full questionnaire, see appendix D.1).

Post-Concert Questionnaire

After the concert, we measured affective states using the Positive Activation Negative Activation Valence scale, short version (PANAVA-KS; Schallberger, 2005). The scale comprises ten bipolar items on a 7-point Likert scale and forms three subscales: Positive Activation (PA), Negative Activation (NA), and Valence (VA). The PA subscale comprises an item with the poles 'tired' and 'wide awake', for example; the NA subscale comprises an item with the poles 'relaxed' and 'stressed', for example; and the VA subscale comprises the two poles 'discontented' and 'contented' as well as 'dissatisfied' and 'satisfied'. We asked further questions about participants' concert experience, if they had the desire to move and dance during the concert on a 5-point scale (1 = *not at all*, 5 = *very much*), their familiarity with the heard music (on a scale from 1 = *I knew all pieces*, to 3 =*I didn't know a single piece*), how they liked the concert on a 5-point scale (1 = *very bad*, 5 = *very good*), and how they felt about experiencing the musicians live on a rating scale (1 = *very bad*, to 5 = *very good*). We additionally asked the participants if they had any impairments due to alcohol or other drugs, or if they had any hearing impairments. We further asked if they had physical limitations that affected their ability to sit or stand. For the full questionnaires, see appendix D.2.1 (seated concert) and D.2.2 (standing concert).

Audio-Visual Recordings

Analogous to the study presented in section 4.1, the concerts were recorded with two cameras. One camera filmed the audience; the other camera filmed the band on the stage.

Procedure

The procedure was the same as in the previous study, with the exception that participants did not receive a financial compensation for their participation (except from the free drink). Concert 1 was seated; Concert 2 took place in the same room but was unseated and the audience had to stand during the concert.

Data Analysis

Musical Feature Extraction and Analysis of Movement Entrainment. The musical feature extraction and the analysis of movement entrainment followed the one described in the previous study in section 4.1.2 .

Statistical Analysis. We analysed the data using IBM SPSS Statistics, JASP (JASP Team, 2024) and the lme4 package (Bates et al., 2015) in R (R Core Team, 2023). We fitted several hierarchical linear models following a forward fitting approach to explain movement entrainment. Missing values were replaced by mean replacement as a maximum of four values were missing in each variable. We tested the following fixed effects: Factors of measurement, musical factors, situational factor, and personal factors. All continuous variables were z-standardised. The random effect, coded as (1 | participant), accounted for individual differences by allowing a random intercept per participant. The null-model only included the random effect. Afterwards, we included the fixed effects step-by-step. We compared the fit of the models using likelihood-ratio tests.

4.2.3 Results

A figure of the estimated marginal means of movement entrainment across the different metrical levels measured at the arm and torso throughout the two concerts for each piece can be found in the appendix (Figure C.1).

Factors of Measurement

First, we included the factors of measurement: the location of measurement Arm (vs. Torso), and the metrical levels Half-Time Level (vs. Standard Beat Level) and Double-Time Level (vs. Standard Beat Level) (M1) which improved the model fit compared to the null model (M0), see Table 4.3. Movement entrainment measured at the arm was significantly higher compared to the measurement at the torso, $t(3287) = 12.04$, $p < .001$. Additionally, the highest degree of movement entrainment was measured at the standard beat level. There was less movement entrainment at the double-time level, $t(3287) = -7.34$, $p < .001$, and even less movement entrainment at the half-time level, $t(3287) = -9.65$, $p < .001$ (Table C.1 in the appendix).

Table 4.3: Hierarchical linear model predicting Movement Entrainment investigating the effects of factors of measurement, musical factors, a situational factor, and personal factors as independent variables.

						Model fit improvement	
	Model	AIC	BIC	Marginal R^2	Conditional R^2	$\chi^2(df)$	p
M0	Movement Entrainment Null Model	8735	8754		.259		
M1 (vs. M0)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level)	8503	8540	.051	.311	238.00 (3)	<.001
M2 (vs. M1)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a]	8148	8277	.122	.384	369.44 (7)	<.001
M3 (vs. M1)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Tempo	8473	8515	.057	.318	32.70 (1)	<.001
M4 (vs. M1)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Slower Than Sweet Spot + Faster Than Sweet Spot	8428	8477	.067	.334	78.88 (2)	<.001

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Table 4.3: Hierarchical linear model predicting Movement Entrainment – *continued from previous page*

	Model	AIC	BIC	Marginal R^2	Conditional R^2	Model fit improvement $\chi^2(df)$	p
M4a (vs. M1)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) × Faster Than Sweet Spot (vs. Sweet Spot) + Double-Time Level (vs. Standard Beat Level) × Slower Than Sweet Spot (vs. Sweet Spot)	8427	8488	.068	.338	48.28 (4)	<.001
M5 (vs. M2)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting)	8131	8217	.188	.384	19.00 (1)	<.001
M6 (vs. M5)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Dance Sophistication (Urge to Dance + Body Awareness + Dance Training + Observational Dance Experience + Social Dancing)	8132	8248	.213	.384	8.93 (5)	.112

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Table 4.3: Hierarchical linear model predicting Movement Entrainment – *continued from previous page*

	Model	AIC	BIC	Marginal R^2	Conditional R^2	Model fit improvement $\chi^2(df)$	p
M7 (vs. M5)	**Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance**	**8125**	**8216**	**.211**	**.384**	**8.16 (1)**	**.004**
M8 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Positive Activation	8125	8223	.214	.384	1.45 (1)	.229
M9 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Trait Empathy	8126	8224	.213	.384	0.94 (1)	.033
M10 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Liking the Concert	8127	8225	.211	.384	0.09 (1)	.077

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Table 4.3: Hierarchical linear model predicting Movement Entrainment – *continued from previous page*

	Model	AIC	BIC	Marginal R^2	Conditional R^2	Model fit improvement $\chi^2(df)$	p
M11 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Liking Jazz Music	8126	8224	.212	.384	0.48 (1)	.488
M12 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Being Familiar With the Music	8126	8224	.212	.384	0.66 (1)	.417
M13 (vs. M7)	Movement Entrainment ~ Arm (vs. Torso) + Half-Time Level (vs. Standard Beat Level) + Double-Time Level (vs. Standard Beat Level) + Piece [a] + Standing (vs. Sitting) + Urge to Dance + Live Experience	8123	8221	.221	.384	4.07 (1)	.004

Note. Every model includes the random effect (1 | participant). The Akaike information criterion (AIC), Bayesian information criterion (BIC), marginal R^2 (variance explained by fixed effects only), and conditional R^2 (variance explained by fixed and random effects) are provided. χ^2 and p values refer to model comparisons to the model stated in brackets using likelihood ratio tests. Null model: Movement entrainment (1 | participant). The best fitting model appears in bold.

[a] Dummy coding for Pieces 2–8, Piece 1 was used as reference category.

Musical Factors

To expand the model with musical factors, we added the factor Piece (M2), which improved the model fit (compared to M1; Table 4.3). The first piece evoked the most movement entrainment compared to the other pieces, for Pieces 2–8: ts(3280) = −15.68 to −6.5, ps < .001 (Table C.2 in the appendix).

To check the effect of tempo instead of piece, we replaced Piece with Tempo (M3). The model fit was worse than the one of M2 (Table 4.3), but it yielded a significant and positive main effect of tempo on movement entrainment. This indicates that pieces with higher tempo evoked more movement entrainment than slower pieces, $t(3286) = 5.73$, $p < .001$ (Table C.3 in the appendix). To further investigate effects of tempo and to check if pieces with tempi in the range of 110–120 BPM (the sweet spot for human motion; Fraisse, 1982; MacDougall & Moore, 2005; M. P. Murray et al., 1964) led to more movement entrainment compared to pieces outside this range, we replaced tempo with two dummy variables, Slower Than Sweet Spot (vs. Sweet Spot) and Faster Than Sweet Spot (vs. Sweet Spot) (M4). We used a tolerance range of 5% (pieces with tempo < 104 BPM: coded as slower than sweet spot; pieces with tempo > 126 BPM: coded as faster than sweet spot). We found a significant and negative main effect for Slower Than Sweet Spot on Movement Entrainment, $t(3285) = -7.80$, $p < .001$, this means that there was less movement entrainment during pieces slower than the sweet spot range. We observed no main effect for Faster Than Sweet Spot (Table C.4 in the appendix).

As it was likely that participants move more to the half-time level during fast pieces and respectively more to the double-time level during slower pieces, we also tested for interaction between Half-Time Level and Faster Than Sweet Spot as well as Double-Time Level and Slower Than Sweet Spot (M4a). Both interactions were not significant (Table C.5 in the appendix).

Situational Factor

As the model fit indices of M3, M4 and M4a were worse than those for M2, we kept Piece as a musical factor and added the concert condition Standing (vs. Sitting) in a next step as the situational factor in our subsequent model (M5), which improved model fit compared to M2 (Table 4.3). Standing had a positive main effect on movement entrainment compared to sitting, $t(68) = 4.61$, $p < .001$ (Table C.6 in the appendix).

Personal Factors

Continuing with personal characteristics of the participants, we added all factors of Participatory Dance Experience and Observatory Dance Experience from the Gold-DSI (Rose et al., 2022) (M6). As the model fit worsened, only the factor Urge to Dance was retained, as it ex-

hibited the largest absolute t value and smallest p value, $t(63) = 1.71$, $p = .092$ (Table C.7 in the appendix), and computed a new model (M7). The model fit now was improved compared to M5 (Table 4.3). Urge to Dance had a significant and positive main effect on Movement Entrainment, $t(67) = 2.88$, $p = .005$ (Table C.8 in the appendix).

We then added the continuous predictors of Positive Activation (M8), Trait Empathy (M9), Liking the Concert (M10), Liking Jazz Music (M11), and Being Familiar With the Music (M12) to the model one by one (Tables C.9–C.13 in the appendix). None of these predictors led to a significant improvement in model fit (Table 4.3). We also added Live Experience to the model to investigate the effect of the evaluation of experiencing the musicians live (M13). It improved the model fit slightly and significantly ($p = .004$). A positive effect of experiencing the musicians live on movement entrainment did not quite reach significance, $t(66) = 1.99$, $p = .051$ (Table C.14 in the appendix).

Final Model

The final model (Figure 4.8) revealed significant main effects for factors of measurement: the location of measurement arm (vs. torso) with a positive main effect indicates that movement entrainment measured at the arm was higher compared to the torso. Movement entrainment at the half-time level (vs. standard beat level) and double-time level (vs. standard beat level) yielded significant negative main effects, meaning that movement entrainment at the standard beat level was highest compared to the half-time and double-time level. Movement entrainment at the double-time level was relatively higher compared to the half-time level. The different pieces predicted movement entrainment significantly as musical factors; movement entrainment during the first piece was the highest compared to the following pieces. As a situational factor, the concert condition standing (vs. sitting) had a positive main effect: there was more movement entrainment in the standing condition compared to the sitting condition. Finally, the personal factor of urge to dance had a positive main effect on movement entrainment, indicating a positive relationship of urge to dance and movement entrainment.

4.2.4 Discussion

We performed an experiment to investigate contributing factors to movement entrainment in an ecologically valid concert setting. We studied two big band concerts with different conditions: one was seated, the other unseated. We investigated different predictors of the measured movement entrainment and identified significant effects of factors of measurement, musical factors, a situational factor, and a personal factor.

Concerning factors of measurement as predictors of movement entrainment, we found an effect of the location of measurement. The measurement at the arm revealed more movement entrainment than at the torso. It is conceivable that this finding is linked to the complexity of

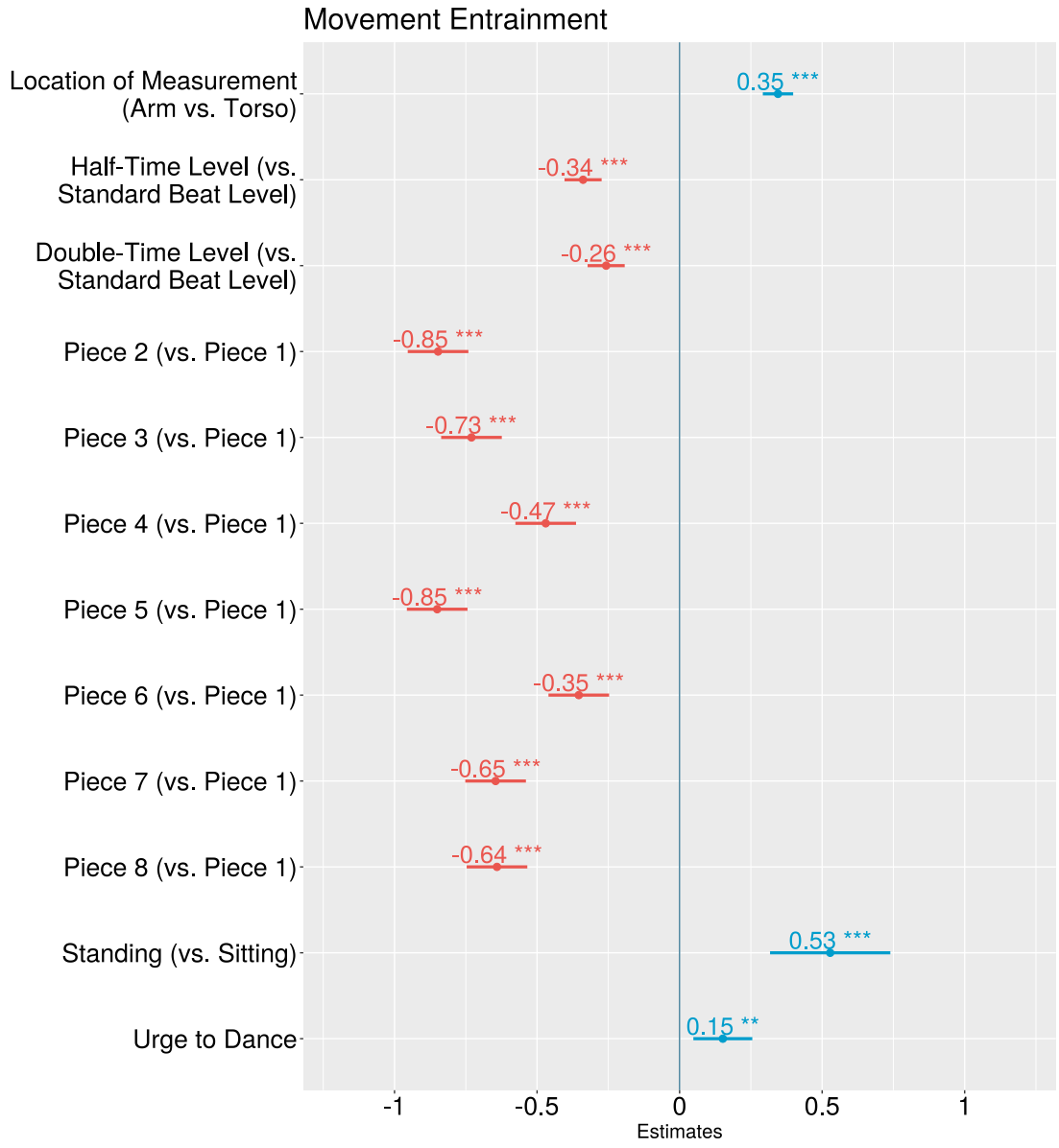


Figure 4.8: Main effects predicting Movement Entrainment.

Note. Estimates of the final hierarchical linear model predicting Movement Entrainment, with Location of Measurement, Metrical Level, musical pieces, the concert condition, and Urge to Dance as predictors. Positive estimates indicate higher movement entrainment compared to the reference category (for categorical predictors) or per 1 standard deviation increase of the predictor (for continuous, z-standardized predictors); negative estimates indicate less movement entrainment. Error bars represent ±1 standard error.

arm movements as they can move independently of other parts of the body and in different directions (Burger et al., 2013).

In terms of the metrical level, people tended to move most on the standard beat level, followed by the double-time and the half-time level. This suggests that overall, people mostly moved to the beat at the tempi of the pieces (82–156 BPM). We also found that the tempo of the music was positively associated with movement entrainment: Faster tempi led to more movement entrainment. Testing the effects of tempi outside the 'sweet spot' range of 110–120 BPM yielded that participants entrained less to slower pieces; there was no effect for faster pieces. These results are partly consistent with those of Burger et al. (2013), who did not find an effect of tempo on movement features. Furthermore, we found no evidence that tempi slower or faster than the 'sweet spot' range led to more movement entrainment at the double-time or half-time level, respectively. To explain this, we must consider that the tempo range of the pieces played in the big band concerts was moderate. There were no pieces with extremely slow or fast tempi. Therefore, for pleasant movement in time with the music, it was not necessary to entrain to other metrical levels than the standard beat level.

We also identified an effect of the pieces as a musical factor: Movement entrainment was highest during the first piece "In the Stone" compared to the other ones. This is not surprising considering the song's description as an "irresistible dancing cut" in the contemporary music magazine Cash Box (Anonymous, 1979). Perhaps the other pieces were simply less danceable than the opening piece, and therefore evoked less movement entrainment.

However, the factor Piece made the best contribution to improving model fit in our model compared to tempo or the tempo sweet spot. This can be explained by the fact that the factor Piece contains much more information than only the tempo and therefore it is the most suitable musical factor we tested to explain movement entrainment. A more detailed and differentiated approach, in which other musical parameters are considered and included in a more sophisticated way, also in the context of groove research (Janata et al., 2012), would be a potential direction for further investigation. Nevertheless, this would extend beyond the focus of the present study.

In the context of situational factors, it is evident that individuals may exhibit more movement entrainment at a standing concert compared to one in which they are seated. Our study provides empirical support for this assumption: Participants in the standing condition showed significantly higher levels of movement entrainment than those in the seated condition. Sitting on a chair during a concert restricts physical movement and may therefore inhibit movement entrainment. This could alter the overall concert experience as a result (this is investigated in the following section 5.1).

We expected several personal factors to have an influence on movement entrainment. Concerning dance sophistication (Rose et al., 2022), only the factor of Urge to Dance pre-

dicted movement entrainment significantly. This indicates that people who generally feel an urge to dance to music also tend to entrain more at a concert. Our findings further suggest that the other factors of participatory and observatory dance sophistication are not that strongly linked to movement entrainment.

Finally, we found preliminary support for the conclusion that the positive evaluation of experiencing the musicians live has a positive effect on movement entrainment. It could be that the unique situation of experiencing the musicians and their playing in a live concert makes people more involved in the music, leading to more movement entrainment.

Although previous research suggests a connection between self-reported positive affect and faster and more complex movements while dancing to music (Saarikallio et al., 2013), we could not find an association of positive activation and movement entrainment in our study. A reason for this finding might be that moving fast or with complex movements to music must be distinguished from movement entrainment. Therefore, we can conclude that positive mood does not seem to be automatically associated with movement entrainment.

Moreover, in contrast to Bamford and Davidson (2017), we could not find a positive association between trait empathy and movement entrainment. One possible explanation for this is that our measure of empathy was shorter, consisting of only four items. This helped to keep the questionnaire as short as possible and made participation in the study more pleasant. Another reason why our findings may contradict to the cited study is that we conducted our study in the field and not in the laboratory. In a situation with higher ecological validity the effect could be weaker, and it is possible that we could not detect it due to a lack of statistical power.

Additionally, we could not find a positive association between being familiar with the music and movement entrainment. This contrasts with the findings of a previous study by Ellamil et al. (2016). The authors report associations between participants' movement in a silent disco and their familiarity with the popular pop and party songs. One possible explanation is that our measure of familiarity was taken after the concert based on all the musical excerpts to avoid disturbing individuals' concert experience. Therefore, it is possible that if we had measured the familiarity of each piece during the concert, a relationship may still have been found. Another possible explanation why we could not find this association may be the specific genre of music we examined. Big bands often play arrangements of famous jazz standards or other popular pieces. That was also the case in our experiment. It is likely that participants who stated to be familiar with the music in our study were familiar with the pieces performed, but probably not with the specific arrangements. The band played an arrangement of The Beatles' "Eleanor Rigby", for example. It is likely that many of the participants knew this song as well as other songs played at the concert and reported this as familiarity in the questionnaire. However, they were probably unfamiliar with the specific arrangements,

which may have resulted in less movement entrainment. Nevertheless, even at a concert at which participants were fans of the performer but were unfamiliar with the songs, they still entrained more to the music than neutral listeners (Swarbrick et al., 2019), which suggests that familiarity with the specific pieces may not be necessary to evoke entrained movement. However, we found no evidence that a preference for either jazz music or the concert is associated with movement entrainment. Concerning liking the music, it is reasonable that liking jazz music is not comparable in intensity and involvement to being a fan of a specific band. Further, the term jazz music unites a wide variety of music and may be not precise enough to capture a preference for big band music. Regarding liking the concert, the lack of variance in the item liking the concert (90% of the participants rated the concert with a 4 or 5 on a 5-point scale) suggests that this variable was influenced by a ceiling effect. This could explain why it was not possible to observe a significant effect of liking the concert on movement entrainment. More work is needed to understand how familiarity and preference affect movement entrainment.

It is important to acknowledge that some of our findings are not generalisable beyond the specific style of music and type of concerts we studied. The finding that people mostly moved to the standard beat level, rather than the double-time or half-time level, and that tempo was positively associated with movement entrainment, was likely influenced by the average tempo of the pieces played during the concert. Concerts with different musical styles and different tempi conventions may lead to other findings here. There are many different concert cultures, and much work remains to be done for a full understanding of movement entrainment during live concerts and its relation to concert experience. This study remains exploratory and probably does not cover all factors that influence movement entrainment at concerts. However, as this is the first study of its kind in an ecologically valid setting, it can be seen as the first step in finding out how and why people move to music at concerts.

Future research should concentrate on different musical genres to be able to make general statements. Due to the lack of variance in the measurement of liking the concert, it could be appropriate to conduct a concert with a more diverse audience, including fans and non-fans, for example (Swarbrick et al., 2019). In light of the theory of the concert frame (Wald-Fuhrmann et al., 2021), future research could also focus more differentiated on the effects of listeners' personality on movement entrainment, as well as on different concert formats.

5 Exploring General and Social Audience Experience in Ecologically Valid Concert Settings

Having focused on movement entrainment in the previous chapter, this chapter now turns to the social experience of a concert. The first part, section 5.1, reanalyses Concert Dataset 2 through the lens of concert experience, exploring how the concert format sitting versus standing shapes the audience's concert evaluation, their affective state after the concert, and their social concert experience. The second part, section 5.2, investigates the relationship between audience movement entrainment and social audience experience as captured by a range of pro-group thinking variables.

5.1 Effects of Standing vs. Sitting on the Audience's Social Experience of the Concert, Their Evaluation of the Concert, and Affective State

This section is based on Concert Dataset 2.

5.1.1 Aims

In the previous section, we reported, among other things, that an unseated concert evokes more movement entrainment compared to a seated concert. However, it is plausible that sitting compared to standing at a concert may have additional effects on the audience. According to the framework of embodied music cognition, bodily movement plays a fundamental role not only in the production of music, but also in its perception (Leman, 2008). Therefore, restricted movement due to seating compared to unrestricted movement when standing could have an effect on the concert experience.

Given the focus of this thesis on the social aspects of the concert experience, we were particularly interested in how the social experience of a concert differs between the two formats. As Pitts (2005) found that being able to see the other audience members and their reactions

can have positive effects on the social concert experience, we expected that standing during a concert could also have a significant impact on the social experience compared to sitting. As people are not seated in fixed rows of chairs, we expected them to be more aware of the other concertgoers. To measure the audience's social experience of the concert, we employed the Social Experience of a Concert Scale (O'Neill & Egermann, 2022). Building on the authors' findings that several variables could potentially influence the social experience of a concert, we sought to investigate how being familiar with other people in the audience (Onderdijk et al., 2021; O'Neill & Egermann, 2022), age and musical engagement (O'Neill & Egermann, 2022) as well as affective state, contribute to the five dimensions of the SECS.

As studies suggest an effect of synchronous movement on pro-group thinking outcomes (e.g., Tarr et al., 2016), it is reasonable to assume that a possible effect of the standing condition on the social experience of a concert – particularly the dimension of Solidarity – would be mediated by a higher degree of movement entrainment. Therefore, we wanted to test if potential effects of the concert condition on the social experience of a concert are mediated by movement entrainment.

Additionally, comparing a seated and an unseated version of a concert raises further questions regarding the concert experience. Theories suggest that the context or frame of a concert can affect the (aesthetic) experience of a concert (Scherer & Zentner, 2001; Wald-Fuhrmann et al., 2026). There is also literature reporting that bodily arousal, which differs when listeners stand or sit during a concert, can affect the emotional experience of music listening (Dibben, 2004; Scherer & Zentner, 2001). We therefore also wanted to investigate how the concert format affects the audience's general evaluation of the concert as well as their affective state after the concert.

On that account, this section re-examines the data previously presented in section 4.2 using new research questions:

1. Are there differences in the social experience of a concert, how the concert is evaluated, and listeners' affective state after the concert between a seated and an unseated version of a concert?

2. Which other variables contribute to social concert experience?

3. Is the potential effect of the concert format on the social experience of a concert mediated by movement entrainment?

5.1.2 Methods

Building on the experiment presented in section 4.2, this study focuses on the questionnaire data collected before and after the two big band concerts, and the audience's movement data.

In the following, we will list parts of the questionnaires that were not included in the methods section of section 4.2, as they were not used in that analysis.

Pre-Concert Questionnaire

In addition to the questionnaires described in section 4.2.2, we used a shortened version of the Goldsmiths Musical Sophistication Index in German language (Müllensiefen et al., 2014; Schaal et al., 2014) to assess Active Musical Engagement (three items on a 7-point Likert scale). For the full questionnaire, see appendix D.1.

Post-Concert Questionnaire

After the concert, we asked participants how many other audience members they knew. Participants stated the (approximate) number. We further asked for their social experience of the concert using a German translation of the Social Experience of a Concert Scale (SECS; O'Neill & Egermann, 2022). This questionnaire with 17 items measures five dimensions of the social experience of a concert: Satisfaction, Attention, Self-Definition, Solidarity, and Depth of Processing. For the full questionnaires, see appendix D.2.1 (seated concert) and D.2.2 (standing concert).

Data Analysis

We analysed the data using the statistics software R (R Core Team, 2023). To investigate the effects of the concert format on the social experience of the concert, the audience's general evaluation of the concert, and the affective state after the concert, we calculated several linear models. We used dummy-coding for the concert format, which was coded as a binary variable (standing as 1; sitting as 0).

To further evaluate the effect of the concert format on social concert experience, we estimated several structural equation models (SEM) using the *lavaan* package (version 0.6–19; Rosseel, 2012) in R. The latent variables were defined based on the theoretically grounded item sets from the SECS questionnaire (O'Neill & Egermann, 2022). As the observed variables included in the SEM were selected based on the literature and were measured on Likert scales, they may be treated as either ordinal or approximately continuous. Therefore, we employed a dual estimation strategy using both WLSMV (Weighted Least Squares Mean and Variance adjusted) and MLR (robust maximum likelihood). The rationale behind this approach was twofold: 1) WLSMV is specifically suitable for small sample sizes and ordinal data (Beauducel & Herzberg, 2006; Li, 2016; Rhemtulla et al., 2012). 2) MLR, on the other hand, is suitable for continuous, partly non-normal data and small samples (Rhemtulla et al., 2012). By applying and comparing both estimators, we were able to examine the robustness of the model results under different assumptions about the measurement level of the variables. This

strategy enhances the methodological transparency of the analysis and results. Model fit was evaluated using common indices including the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR).

During the model estimations, the *lavaan* package produced warnings indicating that the variance-covariance matrix of the estimated parameters is not positive definite. The smallest eigenvalue was marginally negative (−2.510526e-13), suggesting a numerical artefact rather than a substantive issue. Such small negative eigenvalues are not uncommon in SEM analyses with small sample sizes and models with limited indicators.[1]

The *lavaan* package also produced the warning that the covariance matrix of latent variables is not positive definite for some models. The latent covariance matrix included small negative covariances (between Attention and Satisfaction, and Self-Definition and Satisfaction, and, in one case, between Attention and Solidarity). These negative covariances are theoretically plausible given the constructs involved. As model convergence was achieved without issue, we retained the model results but have to regard them with caution.

We first calculated full SEMs (1) with all path coefficients. We observed that one item of the SECS questionnaire (Solidarity_3) showed a relatively low factor loading (<0.4 in both models calculated with WLSMV and MLR), indicating a weak association with its corresponding latent construct. The original English item from the SECS, "I felt committed to the audience," had been translated into German as "Ich fühlte mich dem Publikum verpflichtet." We suspected that this translation does not fully capture the semantic meaning of the original English phrase, with "verpflichtet" possibly conveying a sense of obligation that is too strong or misaligned with the intended meaning of "committed." As a result, we decided to exclude this item from further analyses and calculated reduced SEMs (2) without this item. A comparison of the full models (including all Solidarity indicators) with the reduced version (excluding Solidarity_3) revealed improved model fits.

Subsequently, we removed all paths whose coefficients were not significant at the 5% level and re-estimated the trimmed models (3).

[1] This issue is discussed in online forums such as *Cross Validated*, in which researchers and practitioners note that minor negative eigenvalues, such as the one observed here, are typically due to numerical rounding errors and are generally considered harmless computational artifacts in small-sample SEM, particularly with few indicators, provided the model converges and no inadmissible estimates occur (ambiguditi (https://stats.stackexchange.com/users/398834/ambiguditi), 2026; Kline, 2016).

5.1.3 Results

Effects of the Concert Format and Participant Characteristics on the Audience's Social Experience of the Concert

Concerning the social experience of the concert, we found significant and positive effects on Attention, Solidarity, and Depth of Processing of the concert condition Standing (vs. Sitting). There were no significant effects on Satisfaction and Self-Definition (Table 5.1). This finding indicates that after the standing concert, participants reported paying more attention to, feeling greater solidarity with, and a greater depth of processing of their fellow audience members compared to the seated concert. Satisfaction from being part of the audience and Self-Definition did not differ significantly between the sitting and standing concert formats.

Table 5.1: Results of the linear models examining the effect of the concert condition Standing (vs. Sitting) on the dimensions of Social Experience of the Concert.

Outcome Variables	*B*	*SE*	*df*	*t*	*p*	95% CI
Satisfaction	–0.19	0.19	67	–0.97	.335	[–0.58, 0.2]
Attention	0.95	0.20	67	4.66	<.001	[0.54, 1.36]
Self-Definition	0.11	0.16	67	0.68	.499	[–0.21, 0.44]
Solidarity	0.53	0.18	67	2.89	.005	[0.16, 0.9]
Depth of Processing	0.70	0.21	67	3.48	.001	[0.31, 1.11]

In order to obtain a more comprehensive understanding of the social experience of a concert in a seated and an unseated condition, we estimated multiple structural equation models (SEM), including several exogenous variables. This was particularly important, as the experiment was a quasi-experiment and we did not randomly assign participants to one of the both concert conditions. Participants simply attended one of the two concerts without knowing whether it was seated or unseated and without knowing that this was part of the experiment.

Therefore, in addition to the dummy variable Standing (vs. Sitting), we also included several control variables derived from the literature. The paper in which the SECS was published reported effects of knowing other people in the audience, age, and active engagement with music or musicianship (O'Neill & Egermann, 2022) on some factors of the SECS. We further assumed that positive and negative activation as well as valence, dimension of affective state measured with the PANAVA-KS (Schallberger, 2005), can have an effect on the social experience of the concert. Consequently, we added the following exogenous variables to the SEM: Standing (vs. Sitting), Familiarity With Other Audience Members, Age, Active Engagement With Music, and post-concert measures of Positive Activation, Negative Activation, and Valence.

Table 5.2: Comparison of fit indices across models estimated with WLSMV and MLR.

Estimator	Model	χ^2 (*df*)	*p*	CFI	TLI	RMSEA	SRMR
WLSMV	Full	266.80 (193)	<.001	.932	.952	.076	.121
MLR	Full	276.64 (193)	<.001	.837	.784	.079	.093
WLSMV	Reduced	202.09 (171)	.052	.970	.979	.052	.107
MLR	Reduced	234.12 (171)	.001	.872	.826	.073	.078
WLSMV	Trimmed	346.80 (158)	<.001	.821	.864	.134	.143
MLR	Trimmed	252.30 (180)	<.001	.852	.822	.076	.100

Note. Models were estimated using Weighted Least Squares Mean and Variance adjusted (WLSMV) and robust Maximum Likelihood (MLR). Fit indices: CFI = Comparative Fit Index, TLI = Tucker–Lewis Index, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardised Root Mean Square Residual.

Comparing the full, reduced, and trimmed SEMs estimated with the WLSMV and MLR estimator, we found that the reduced model estimated with the WLSMV estimator indicated the best overall fit indices (Table 5.2). This model contains all regression paths of the exogenous variables and excludes one Solidarity item. An overview of the model can be seen in Figure 5.1 (please note that only the significant regression paths are displayed in the figure to make it easier to read). Detailed results of the structural regressions, including standardised coefficients and significance levels, are presented in Table C.15 in the appendix.

As the linear models have already highlighted, the SEM revealed that Standing (vs. Sitting) had a significant and positive effect on the dimensions Attention, Solidarity, and Depth of Processing of the SECS. The model also revealed that, in addition to Standing (vs. Sitting), three other exogenous variables had significant and positive effects on the latent construct of Solidarity: Familiarity With Other Audience Members, Active Engagement With Music, and Positive Activation. This means that familiarity with other people in the audience was positively associated with feelings of solidarity towards fellow audience members. Furthermore, being musically active and being in a positive mood was linked with stronger feelings of solidarity.

All other paths of exogenous variables on the latent constructs of the SECS were not significant. Thus, the latent construct Solidarity was particularly well explained by the predictors in the SEM, with a standardised R^2 of .79. This indicates that 79% of the variance in the latent construct Solidarity is explained by the model. In contrast, the R^2 values for the other latent constructs were considerably lower, ranging from .17 to .51, indicating lower levels of explained variance.

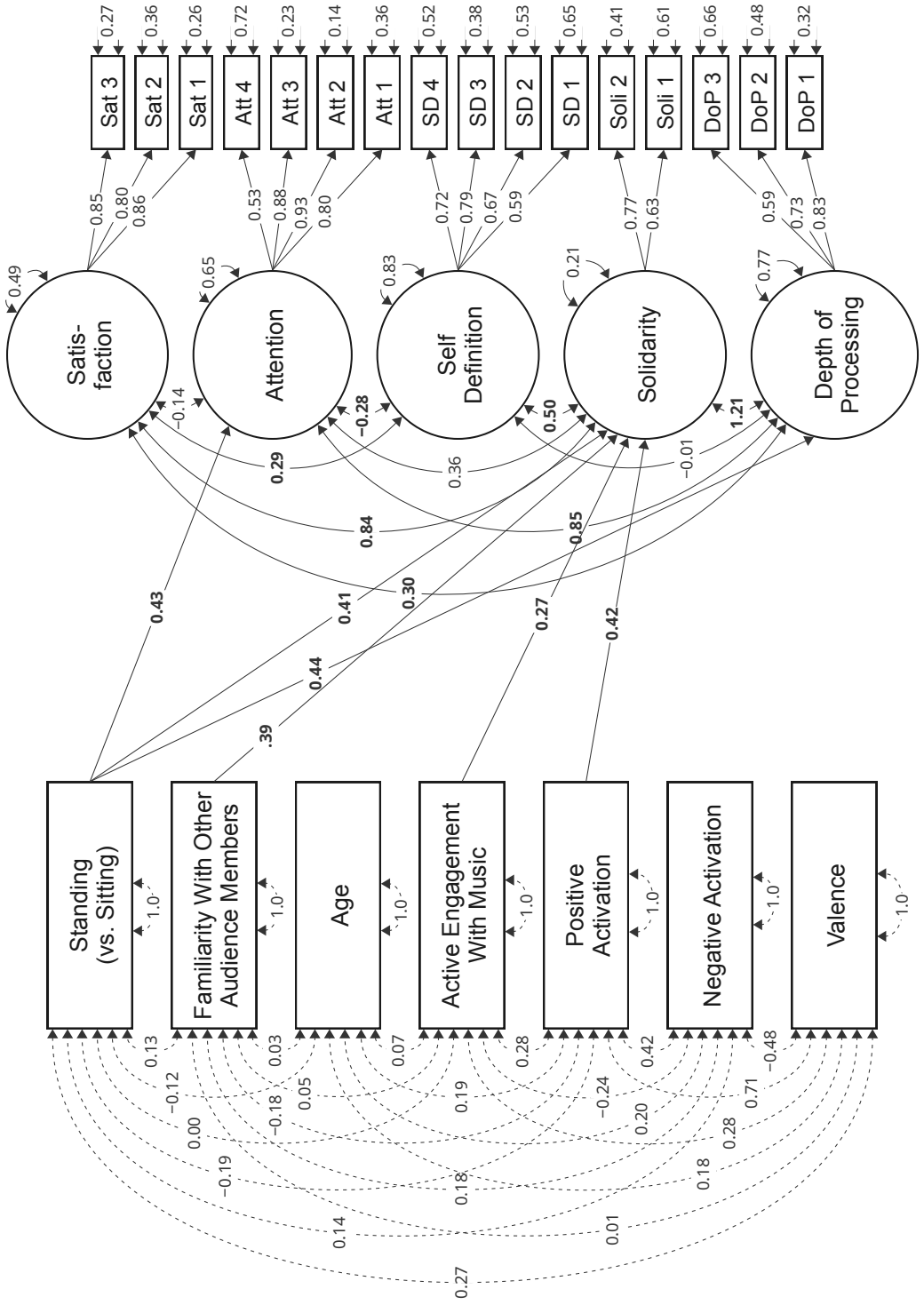


Figure 5.1: The structural equation model predicting Social Experience of the Concert.

Note. For improved visual clarity, only significant regression paths ($p < .05$) are included in the SEM diagram.

Relationship Between the Concert Condition, Movement Entrainment, and the Social Experience of the Concert

To test whether the effect of standing on the social experience of a concert is mediated by movement entrainment, we aimed to conduct mediation analyses for the three different outcome variables that were significantly influenced by Sitting (vs. Standing) in the SEM: Attention, Solidarity, and Depth of Processing. However, since there was a non-significant trend correlation between the variables Movement Entrainment and Solidarity (r = 0.228, p = .059), and no significant correlation between Movement Entrainment and Depth of Processing (r = 0.169, p = .166), we only conducted a mediation analysis for the outcome variable Attention (correlation with Movement Entrainment: r = 0.313, p = .009) to learn whether the effect of Standing (vs. Sitting) on Attention is mediated by Movement Entrainment. We used nonparametric bootstrapping with 5000 resamples.

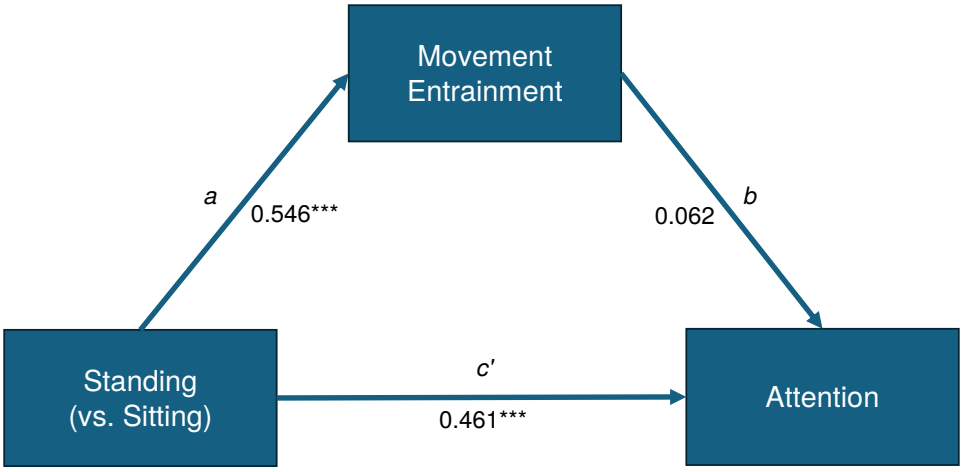


Figure 5.2: Standardised results of the mediation model with the effect of Standing (vs. Sitting) on Attention mediated by Movement Entrainment.

***p < .001.

Standing (vs. Sitting) significantly increased Movement Entrainment (b = .008, p < .001; path a in Figure 5.2). Increases in Movement Entrainment did not significantly increase Attention when entered in the mediation model together with Standing (vs. Sitting) (b = 8.006, p = .682, path b in Figure 5.2). Standing vs. Sitting significantly increased Attention when controlled for change in Movement Entrainment (b = .887, p = .001, path c′ in Figure 5.2). The indirect effect via Movement Entrainment was not significant (ab = 0.065, 95% CI [−0.224, 0.356], p = .677), indicating no evidence for mediation and that the effect of Standing (vs. Sitting) on Attention is predominantly direct.

Effects of the Concert Format on the Evaluation of the Concert and the Audience's Affective State

There was no significant effect of the concert format on the evaluation of the concert (Table 5.3), meaning that there was no difference in terms of the general evaluation of the concert between the seated and the unseated concert.

Moreover, results indicated no effect of the concert format on Positive Activation or Negative Activation, but the concert format standing had a significant negative effect on Valence compared to the sitting condition (Table 5.3). This means that there was no difference between the two concerts in terms of positive and negative activation after the concert. However, after the standing concert, participants were less content and satisfied compared to the seated concert.

Table 5.3: Results of the linear models examining the effect of the concert condition Standing (vs. Sitting) on the evaluation of the concert and affective state.

Outcome variables	*B*	*SE*	*df*	*t*	*p*	95% CI
Evaluation of the concert	–0.15	0.19	67	–0.80	.424	[–0.52, 0.22]
Positive Activation	–0.42	0.26	67	–1.59	.116	[–0.95, 0.11]
Negative Activation	0.27	0.24	67	1.12	.265	[–0.21, 0.75]
Valence	–0.64	0.28	67	–2.27	.026	[–1.20, –0.08]

5.1.4 Discussion

In this section, we analysed the effects of sitting compared to standing in two big band concerts. It is the first empirical study to investigate differences between a seated and an unseated concert in an ecologically valid concert setting. In our explorative approach, we wanted to investigate the effects of standing compared to sitting on the audience's social experience of the concert, the general evaluation of the concert, and the audience's affective state after the concert. We were further interested in other variables contributing to the social experience of a concert and if the effects of standing on the social concert experience are mediated by movement entrainment.

To measure the social experience of the concert, we applied the Social Experience of a Concert Scale by O'Neill and Egermann (2022). This was the first time the questionnaire was used outside of Western classical concerts. Even though the SECS was developed in the context of classical music, the overall good fit values of the SEM revealed that it is possible to apply it to other concert contexts. We found significant positive effects of the concert condition Standing (vs. Sitting) on the latent constructs of Attention, Solidarity, and Depth of Pro-

cessing, while there were no significant effects on Satisfaction and Self-Definition. However, this means that overall, the standing concert was the more social experience for concertgoers.

The higher levels of attention for the fellow audience members in the unseated concert condition can be explained by the fact that the standing audience members have to orientate themselves in the room during the concert. Standing requires paying attention to the surroundings to avoid getting in anyone's way. Being more attentive to the surroundings and the other audience members can also be described as a prerequisite for the processing of other audience members, for being able to recall and recognise them. This can explain the higher levels of depth of processing after the standing compared to the seated version of the concert. Finally, people can only feel a bond and solidarity with people they have noticed to some extent. Even though the paper in which the SECS was published does not describe a path model stating that more attention to others leads to a deeper processing of others, which in turn leads to greater solidarity (Attention –> Depth of Processing –> Solidarity), the authors report correlations among these three constructs. This supports the idea that such a process is nevertheless conceivable and could be investigated in further studies.

However, the overall finding that the standing condition provided a more social experience for audience members aligns with Pitts (2005), who found that being able to see other audience members and their reactions can enhance both the social experience of a concert and the sense of being part of an audience. In a seated concert, in which chairs are usually arranged in fixed rows – which was also the case in the seated condition –, it is more difficult to observe the reactions of others. In an unseated concert, as described previously, the audience has to look around to avoid bumping into other people or stepping on their feet. This also makes it more likely that audience members will pay closer attention to how others react to the music than they would at a seated concert.

In the SEM, we found that, besides the concert condition, a number of exogenous variables predict solidarity. The result that familiarity with other audience members has a positive effect on solidarity is unsurprising. Most participants who stated that they were familiar with other audience members are likely to have attended the concert with friends, family, fellow students, or colleagues. It is also highly probable that they *liked* these people, which leads to stronger bonds and a greater sense of solidarity. These findings can also be likened to results reported by Onderdijk et al. (2021) who investigated social connectedness in three livestreamed concerts of different genres. They found that knowing other audience members was a positive predictor of social connection with the audience. However, comparing this with the findings of O'Neill and Egermann (2022) reveals deviating results. The authors report that co-attendance (knowing other people in the audience and attending the concert with them) was associated with lower levels of attention and solidarity. They explain this finding with the assumption that attending a concert with others may lead to more attention

to only their responses (Boothby et al., 2014) and, as a result, less awareness of (and solidarity with) the other audience members. At this point, it should be noted that the SECS uses the general term "the audience" ("das Publikum") to ask for attention (e.g., "I closely watched how the audience behaved") or solidarity (e.g., "I felt a bond with the audience"). This wording leaves it unclear, however, whether participants interpreted the statements they had to rate in the questionnaire as referring to all audience members in general, only those sitting or standing nearby, or merely people they knew.

Further, our study revealed a positive effect of active engagement with music on solidarity with the other audience members. This can be explained by the fact that, generally, participating in musical activities can facilitate social bonding (Freeman, 2001; Kreutz, 2014; Savage et al., 2021; Tarr et al., 2014). Therefore, it is possible that participants with a higher degree of active musical engagement reported generally higher levels of solidarity with their fellow audience members in our experiment. Since we conducted our study at a music institute, it is possible that most participants were music students who knew each other from classes and ensembles, which may have influenced the observed relationship between active musical engagement and solidarity. However, only 14% of the participants reported explicitly that they studied music. Another 10% reported that they were studying to become teachers but did not specify their subject(s). Some of these may include music. Therefore, it is rather unlikely that the positive effect of musical engagement on solidarity can be solely attributed to prior knowledge of fellow attendees from their studies or music projects. In comparison, O'Neill and Egermann (2022) found a positive effect of musical training on Depth of Processing, but not on Solidarity.

We also found a positive effect of Positive Activation on Solidarity, suggesting that being in a positive mood is related to a bond and solidarity with the fellow audience members. This can be explained by research on collective emotions, which suggests that joint emotional experiences can strengthen feelings of solidarity within groups (von Scheve & Salmela, 2014). It is also possible that the effect is bidirectional and that feeling a bond with other audience members positively affects positive activation (Baumeister & Leary, 1995). The relationship between positive affective state and social connection in the context of the effects of movement entrainment (Tarr et al., 2016; Wiltermuth & Heath, 2009) will further be investigated in section 5.2.4. Negative Activation and Valence did not affect the social experience of the concert.

Further, even though O'Neill and Egermann (2022) report that older participants reported increased Solidarity and Depth of Processing, we cannot confirm this with our study. To explain this finding, it has to be noted that the age range of the sample by O'Neill and Egermann (2022) was broader. They divided the participants into four age groups for their analysis: 23 years or younger, 23–55 years, 56–75 years, and over 75 years. However, our

sample can be described as rather dichotomous: A large group of younger participants (20–33 years old: 90%) and a smaller group of older participants (52–69 years old: 10%). There were no participants between 34 and 51 years old. It is therefore possible that we did not find an effect of age due to our sample composition.

It is remarkable that in the SEM all exogenous variables with a significant effect on the social experience of a concert (apart from Standing vs. Sitting, which also affected Attention and Depth of Processing) revealed positive effects on the dimension of Solidarity. No other significant effects were indicated by the model. This means that Solidarity is influenced by a particularly large number of variables. At the same time, the comparatively high R^2 suggests that Solidarity was also relatively well explained by our model.

Even though studies indicate that moving in synchrony can foster pro-group thinking (e.g., Tarr et al., 2016), we cannot confirm this with the data we collected in this study. Data revealed a non-significant trend relationship between movement entrainment and solidarity. For the other two dimensions of the SECS that were affected by Standing (vs. Sitting), only Attention showed a significant positive relationship with Movement Entrainment. A mediation analysis revealed that the positive effect of Standing (vs. Sitting) on Attention is not mediated by Movement Entrainment. However, it is possible that the SECS was not the correct instrument to measure pro-group thinking and, explicitly, social connection towards the other audience members, as it was primarily developed to measure general social audience experience during concerts, even though solidarity with other audience members is one of its dimensions. Therefore, it is possible that pro-group thinking with other audience members has to be operationalised differently. It is also possible that we did not find a relationship between solidarity and movement entrainment because the two big band concerts did not evoke enough movement entrainment and synchronous movement. Participants may also have felt inhibited about moving and dancing at the concert. A concert of a different musical genre may reveal different results.

Conceptualising the concert condition standing vs. sitting as part of the context of music listening or the concert frame that can affect the (emotional) response to music and the aesthetic experience of a concert (Leman, 2008; Scherer & Zentner, 2001; Wald-Fuhrmann et al., 2021), we were interested in effects on the general evaluation of the concert and the affective state after the concert. We found that there was no difference in terms of concert evaluation between the two conditions, meaning that this aspect of the concert frame did not affect the evaluation of the concerts we studied. This finding may reflect that the big band concert occupies a middle ground between concerts at which seated or unseated formats are preferred. The big band performed both danceable pieces, particularly the first piece (see section 4.2), and pieces that evoked less movement entrainment. The latter perhaps encouraged the audience to enjoy the music in a more relaxed manner. For this reason, it is possible that

the audience did not have a general preference for sitting or standing, meaning that the concert condition did not affect their evaluation of the concert. However, as already mentioned in section 4.2, we have to consider the possibility of a ceiling effect with regard to the item "liking the concert", as 90% of the participants rated the concert with a 4 or 5 on a 5-point scale.

We also found no effect of the concert format on positive or negative activation after the concert. This means that, even though bodily arousal may have differed between the concert conditions, the affective state was not affected by the concert condition. This complements the findings of Dibben (2004) who found effects of bodily arousal on perceived musical emotions. The finding that there was no difference in positive and negative activation also supports our previous interpretation that there was perhaps no strong general preference for sitting or standing at both big band concerts.

However, we did find a significant effect of the concert format on valence. After the sitting concert, valence was higher compared to the standing concert. This finding can be explained by the fact that both concerts took place on Wednesday evenings. Participants may have been tired after a full day at work and may therefore have preferred to sit down. Consequently, standing without a seat may have affected their content and satisfaction levels.

While the present study provides novel insights into the effects of an unseated versus a seated concert, several limitations should be noted. Regarding our analysis of the overall evaluation of the concert, we only asked for a general evaluation of the concert in the questionnaire after the concert had ended, which may have affected the results as there is evidence that we tend to remember and evaluate events based on their ending (i.e., the most recent part; Fredrickson, 2000; Schäfer et al., 2014). Therefore, asking for evaluations after each piece would have been more precise and would have provided us with more information about effects of the concert condition with regard to every single piece. However, it would also have involved interrupting the concert several times. As our goal was to keep the concert as ecologically valid as possible, we decided only to ask the audience to evaluate the concert once after it had ended, which entails a certain degree of inaccuracy.

Regarding the sample size, the study included a relatively small number of participants. Even though the SEM indicated overall good fit values, the sample size was somewhat too small for such a complex model. This could also be the reason for the reported error messages.

We found that standing increased audience attention to other attendees using the SECS. However, this only captures part of social attention. In particular, we did not measure the audience's attention to the musicians. It is conceivable that standing also affects the attention towards the performers, which could provide further insights into the audience's overall concert experience. An investigation of this could be included in a follow-up study.

It should also be noted that the reported effects of standing versus sitting and their influence on the social concert experience were observed in the context of a specific concert and also a specific concert culture. Big band performances typically include pieces of varying styles and degrees of danceability, some of which explicitly draw on traditions of dance music. As such, big band concerts may occupy an intermediate position between concert formats that are more suitable for sitting and those that are more suitable for standing, since certain pieces may invite seated listening while others encourage movement and dance. To gain a more comprehensive understanding of effects of sitting and standing at concerts, it is therefore essential to apply the present methods to other concert settings and musical cultures.

Overall, this study is the first to investigate the effects of standing vs. sitting in a live concert setting and is an important contribution to current concert research, underlining that this part of the context or concert frame does affect the social experience of a concert. This is particularly important as the social experience of a concert was found to positively influence people's overall enjoyment of a concert (O'Neill & Egermann, 2022). Though we did not find that standing compared to sitting affected the overall concert evaluation, the positive effect of standing on the social experience of a concert could be considered by concert organisers when designing (new) concert formats.

This study focusses primarily on the social experience of a concert and therefore applied the Social Experience of a Concert Scale developed for this context. As noted above, our data revealed a non-significant trend relationship between movement entrainment and the Solidarity dimension of the SECS. As the Solidarity dimension was considered to most closely reflect the concept of 'social connection', a construct – beyond other pro-group thinking outcomes – that previous research has shown to be associated with joint movement, the absence of a robust relationship was unexpected. Two plausible explanations for this have been offered. First, the big band concert setting may not have elicited sufficient spontaneous dancing or coordinated movement to produce a measurable effect. Second, the dimension of Solidarity may not adequately capture all or enough facets of pro-group thinking. As such, we suggest examining this issue more closely in a follow-up experiment. This experiment should employ an alternative approach to evaluate social connection and pro-group thinking in relation to audience members and musicians within a more distinct concert setting. This study is presented in the subsequent section.

5.2 Positive Relationships Between Audience Movement Entrainment and Pro-Group Thinking

This section is based on Concert Dataset 3.

5.2.1 Aims

This study further investigates the relationship between audience members' movement entrainment and social audience experience. Given that earlier research indicates that engaging in shared, synchronous movement can foster pro-group thinking (e.g., L. Cross et al., 2019; Tarr et al., 2016; Wiltermuth & Heath, 2009), the aim of this study is to investigate this relationship in an ecologically valid concert, during which people move together to the live music, since most prior studies have demonstrated this association primarily in highly controlled laboratory settings.

The previous study of this thesis reported a non-significant trend correlation between movement entrainment and a feeling of solidarity with the other audience members at big band concerts. It was therefore suggested to 1) conduct a study in another concert context, and 2) use a different method to evaluate pro-group thinking. For this reason, we conducted the following study at a real-world indie-pop concert that was unseated and at which moving together to the music and dancing along may be more typical audience behaviour. To measure pro-group thinking, we employed more specific measurement instruments that have already been used in other studies. With an adapted version of the visual IOS Scale (Aron et al., 1992), we measured the social closeness or inclusion of both the other audience members and the band in the self of the audience. To measure social connection, both towards the audience and towards the musicians, we asked explicitly for the felt connection on a rating scale. We hypothesised that there is a positive relationship between movement entrainment and IOS as well as social connection both among the audience members and between the audience and the musicians. Additionally, we sought to identify further variables that contribute to social connection, as existing evidence suggests that factors such as positive affect (Berkowitz, 1987; George, 1991; Taylor et al., 2020), familiarity with the musicians or other audience members (Onderdijk et al., 2021; Swarbrick & Vuoskoski, 2023), active musical engagement (O'Neill & Egermann, 2022; Perkins et al., 2021), and age (O'Neill & Egermann, 2022) influence social connection.

As the audience is characterised by its shared membership of a social group and its shared experience of the concert, we further wanted to examine the social relationships within the audience and their link to movement entrainment in even greater detail. We therefore measured further pro-group thinking outcomes, namely trust, likeability, and similarity, in rela-

tion to the other audience members and expected to find a positive relationship with movement entrainment.

5.2.2 Methods

Participants were informed about the study procedure in advance and gave their written consent. The study was approved by the ethics committee of the DGM (the German Association for Music Psychology) and was performed in accordance with their guidelines and regulations. These also refer to the regulations of the DGPs (the German Psychological Society).

Participants

We collected data from 83 participants, but due to a technical issue with the recording and incomplete datasets resulting from missing post-questionnaires, we were only able to use the data of 39 participants (female = 25, male = 13, other = 1; mean age: 29.1 years, SD = 6.9) recruited via social media and, predominantly, in person on arrival at the venue. All participants provided written informed consent prior to their involvement in the study. Participants did not receive any compensation for their participation. We used short scales with three items per subscale of the German version of the Goldsmiths Musical Sophistication Index (Müllensiefen et al., 2014; Schaal et al., 2014) to assess the participants' general musical sophistication (M = 14.15, SD = 5.2; extrapolated to the original 18 items as it is a sum score: falls between the 53rd and 54th percentile of the percentile norms reported for the Gold-MSI normative sample) and active musical engagement (M = 16.2, SD = 2.6; extrapolated to the original 9 items: between the 73rd and 74th percentile of the percentile norms reported for the Gold-MSI normative sample). This suggests that participants were slightly more musically sophisticated and considerably more musically active than the Gold-MSI normative sample.

Stimuli

The experiment was conducted during a concert of the indie-pop band Walking on Rivers at a cultural centre in the city of Bochum in the German Ruhr area on a Friday evening in December 2023. Concertgoers had purchased their tickets in advance or at the box office on the day of the concert. Doors opened at 7:30 PM, the support act, the Dutch indie-electro-band Engelbert, started their performance at 8:15 PM. The concert of the main act Walking on Rivers started at 9:20 PM and lasted for one hour and twenty minutes (for the set list with BPM values, see Table 5.4). The concert was attended by approximately 300 people in the audience, and drinks were provided at a bar. As some of the participants arrived during or after the performance of the support act, we decided to use only the movement data collected

during the performance of the main act. Two photographs of the concert are presented in Figure 5.3.

Table 5.4: Set list and BPM values of the pieces performed at the indie-pop concert.

Piece No.	Piece Title	BPM Value
1	Erpelparka	174
2	Good Times	133
3	In Vain	112
4	Stay in the Box	100
5	Selfmade Delusion	140
6	Die Bude Brennt	138
7	Wherever I Go // You Follow	122 / 84
8	Gone to Waste	160
9	Off the Trails	111
10	Knallgasprobe	128
11	Lights Go Out	132
12	Feeling in My Bones	134
13	Rote Augen Helles Licht	168
14	Overachiever	120
15	Time to Lose Control	118

Movement Data

We used the same setup for measuring movement data as described in Section 4.1.2 and 4.2.2. Since we only had 45 pairs of the Shimmer GSR + and Shimmer ECR devices available, we decided to double the sample size by equipping participants with only one such device each. Whether participants were equipped with a GRS + sensor on their arm or an ECG sensor on their torso was assigned at random. The GSR + devices also measured skin conductance on the index finger and middle finger; the ECG devices also measured an electrocardiogram with two electrodes placed on the participants' chest. However, this data are not included in the following analysis.

Pre-Concert Questionnaire

Before the concert, we asked for the participants' age, and whether they had come alone or accompanied. To assess musical sophistication, we used a shortened version of the German



Figure 5.3: Photographs of the indie-pop concert.

Note. Top: The band Walking on Rivers performing. Bottom: The audience during the concert. Photos by Martin Hammeke.

version of the Gold-MSI (Müllensiefen et al., 2014; Schaal et al., 2014). The full questionnaire can be found in the appendix F.1.

Post-Concert Questionnaire

After the concert, we measured participants' current affective state by using the German version of the Positive and Negative Affect Schedule PANAS (Breyer & Bluemke, 2016; Watson et al., 1988). PANAS measures positive and negative affect on two separate scales. It comprises 10 adjectives for positive (e.g., strong, proud), and 10 adjectives for negative (e.g., afraid, upset) affective states. Participants rated the extent to which they experienced each emotion at the time of measurement on a 5-point scale (1 = *very slightly or not at all*, 5 = *extremely*).

To measure pro-group thinking in relation to the band and the audience, we adapted several items, almost all of which had previously been used by Tarr et al. (2016) in their silent disco study. Pro-group thinking towards the band was measured in two ways: 1) by a modified version of the Inclusion of Other in the Self (IOS) Scale (Aron et al., 1992). Participants were presented with seven pairs of circles with an increasing degree of overlap between them. Each first circle was labelled "me", the second circle "band". 2) by explicitly asking how connected they felt with the main act during the concert on a 7-point scale (1 = *not at all*, 7 = *very much*).

Pro-group thinking towards the audience was measured in five ways: 1) by the IOS Scale, with the difference that in this case the second circle was labelled "audience". We also asked for 2) social connection and, additionally, 3) trust ("How much would you trust the other audience members"; adapted from Wiltermuth & Heath, 2009), 4) likeability ("How likeable were the other people in the audience?"; adapted from Hove & Risen, 2009), and 5) similarity ("How similar do you feel to the other participants?"; adapted from Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009) on 7-point scales (1 = *not at all*, 7 = *very much*).

Additionally, we asked further questions about their concert experience, if they moved together with the other people in the audience and with the music on 5-point scales (1 = *not at all*, 5 = *very much*), as well as how familiar they were with the music they heard and the main act itself, and how they liked the main act and the concert in general on 4-point scales (1 = *not at all*, 4 = *very much*). All the questions related to the main act.

We also asked participants how many people they knew in the audience and how many members of the main act they knew personally. Finally, we asked if they had any restrictions due to alcohol or other drugs or with their hearing. The compete questionnaire can be found in the appendix F.2.

Audio-Visual Recordings

The concert was recorded with three cameras, one facing the audience and two facing the performers on the stage throughout the duration of the concert. We were additionally provided with the soundboard recording.

Procedure

Participants were greeted at the entrance, received an information sheet about the experiment, and filled out the consent form. They then filled out the pre-concert questionnaire for approximately 10 minutes. Participants could choose between a paper-and-pencil version and a digital version online. To be able to assign the questionnaires to the movement data, we used anonymous IDs generated by the participants themselves. Subsequently, participants were fitted randomly with one of the two device types. Participants were not restricted in their movement by the devices worn on their bodies. After the measuring device was attached (to the arm or torso), the participants were allowed to move freely in the building. No additional instructions were provided, nor were they encouraged to adopt any specific behaviours or movements during the concert. Participants were allowed to leave the concert at any time they wanted and to finish the experiment before it ended.

After the concert, participants filled in the post-concert questionnaire. This took approximately 10 minutes. After completing the questionnaire, the participants returned the measuring device and were thanked.

Data Analysis

Analysis of Movement Entrainment. We used the same analysis for movement entrainment as reported in section 4.1.2. As the band played using a click track (a metronome used during the performance), we could rely on precise and consistent tempos. To account for the expected differences in movement entrainment measurements between sensor locations, with lower values expected for the torso and higher values for the arm (see section 4.2), we used standardised data in all analyses using mean movement entrainment values. Specifically, we z-standardised the mean values of movement entrainment separately for participants wearing sensors on the arm and those wearing sensors on the torso, and then combined the two groups.

Statistical Analysis. To analyse the data, we used IBM SPSS Statistics, JASP (JASP Team, 2024), and the lme4 package (Bates et al., 2015) in Rstudio (R Core Team, 2023).

5.2.3 Results

A figure illustrating the estimated marginal means of movement entrainment at the different metrical levels measured at the arm and torso over the course of the concert for each piece can be found in the appendix (Figure E.1).

Significant Movement Entrainment

To confirm our measurement of movement entrainment and to replicate the findings from the study in section 4.1.3, we compared the calculated movement entrainment to the BPM values of the songs that were played during the concert with values of movement entrainment calculated for control BPM values. We conducted the same analysis as in section 4.1.3. After Bonferroni corrections ($\alpha = 0.0083$) we found that the mean values of movement entrainment calculated for the target BPM values were consistently significantly higher compared to movement entrainment calculated for the control BPM values (t values ranging from 3.83 to 5.75, p values $< .002$; see Figure E.2 in the appendix).

We also tested the relationship between movement entrainment and self-reported movement to music as well as movement with the other people in the audience. We calculated Pearson's correlations, revealing a significant positive relationship between movement entrainment and self-reported movement to the music, $r(37) = .378$, $p = .018$, as well as movement entrainment and self-reported movement with the other audience members, $r(37) = .493$, $p = .001$ (see Figure E.3 in the appendix).

Association Between Movement Entrainment and Pro-Group Thinking

We conducted several correlation analyses to examine the relationship between movement entrainment and pro-group thinking. A correlation matrix between all items is presented in Figure 5.4. It should be noted that, given the number of correlations examined, this analysis is exploratory and the results should be interpreted with caution, since no Bonferroni correction was applied to account for the multiple correlation tests performed.

Pro-Group Thinking in Relation to the Band. To investigate associations between movement entrainment and pro-group thinking in relation to the band, we considered the correlations between movement entrainment and the following two items concerning the band: 1) the IOS Scale measuring inclusion of the band in the self, and 2) the verbal measure of explicit social connection with the band. The correlation between movement entrainment and the IOS Scale was not significant, while there was a positive and significant correlation between movement entrainment and explicit social connection with the band (see Figure 5.4).

Pro-Group Thinking in Relation to the Other Audience Members. To examine the association between movement entrainment and pro-group thinking in relation to the other audience

members, we considered the correlations of movement entrainment and the following five items concerning the other audience members: 1) the IOS Scale measuring inclusion of the other audience members in the self, 2) the verbal measure of explicit social connection with the audience, 3) trust, 4) likeability, and 5) similarity. The correlations were positive and significant for each of the pairs of movement entrainment and the IOS Scale, explicit social connection, and similarity. The correlation between movement entrainment and likeability and between movement entrainment and trust was not significant (see Figure 5.4).

Investigating Effects on Social Connection

To further investigate our research question, we built a multivariate hierarchical linear model to test for significant effects on the dependent variable of social connection. We chose to focus on social connection because we had surveyed it in the questionnaire in relation to both the audience and the band, and because it has been used in several previous studies (e.g., Onderdijk et al., 2021; Swarbrick & Vuoskoski, 2023; Tarr et al., 2016), allowing for comparisons with existing research.

We used dummy coding for the target of social connection and referred to social connection with the audience; social connection with the band was used as reference category. To investigate the effects of movement entrainment and other predictors on the intensity of social connection, we fitted several hierarchical linear models in a forward fitting approach. We used the lmer function from the lme4 package (Bates et al., 2015) in R (R Core Team, 2023). All continuous variables were z-standardised. To account for variability across individuals, the analysis included a random intercept for participant ID. As a baseline model, we specified a null model that included only the random intercept for the grouping variable 'ID'. The model fits were evaluated through likelihood-ratio tests, enabling a comparison of their relative fit.

Social Connection With the Audience vs. the Band. To assess whether participants felt a stronger social connection to the audience or the band, we incorporated the dummy variable Audience (vs. Band) to the model (M1), which improved model fit compared to the null model (M0, see Table 5.5). The dummy variable Audience (vs. Band) revealed a significant negative effect on Social Connection, $t(38) = -4.08$, $p = <.001$ (see Table E.1 in the appendix), indicating that participants felt more connected to the band than to the other people in the audience.

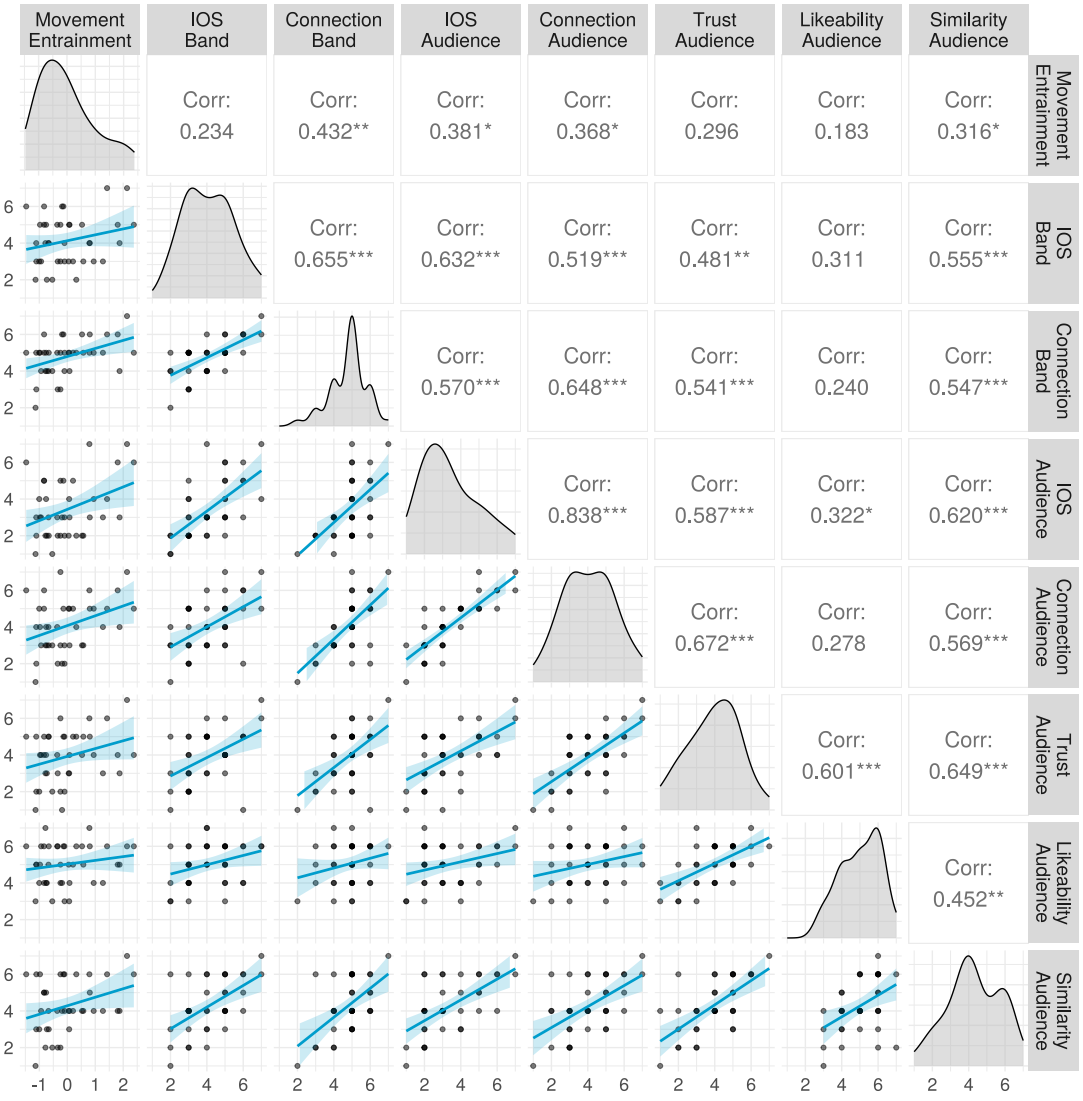


Figure 5.4: Correlation matrix of all pro-group thinking items and Movement Entrainment.

Note. Matrix of pairwise relationships among variables. The lower triangle shows scatterplots with fitted regression lines and shaded 95% confidence intervals, the diagonal displays density estimates, and the upper triangle presents Pearson correlation coefficients with significance levels indicated.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 5.5: Multivariate hierarchical linear model predicting Social Connection.

	Model	AIC	BIC	Marginal R^2	Conditional R^2	Model fit improvement $\chi^2(df)$	p
M0	Social Connection Null Model	218	225		.491		
M1 (vs. M0)	Social Connection ~ Audience (vs. Band)	208	218	.078	.639	12.02 (1)	<.001
M2 (vs. M1)	Social Connection ~ Audience (vs. Band)+ Movement Entrainment	205	216	0.212	.644	5.59 (1)	.018
M3 (vs. M2)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Audience (vs. Band) × Movement Entrainment	208	223	.212	.639	1.82 (1)	.177
M4 (vs. M2)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect	195	209	.402	.645	12.03 (1)	<.001
M5 (vs. M4)	**Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience**	**190**	**206**	**.496**	**.646**	**7.02 (1)**	**.008**
M6 (vs. M5)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience + Audience (vs. Band) × Familiarity with Audience	193	212	.495	.643	1.62 (1)	.202

- continued on next page -

Table 5.5: Multivariate hierarchical linear model predicting Social Connection – *continued from previous page*

	Model	AIC	BIC	Marginal R^2	Conditional R^2	Model fit improvement $\chi^2(df)$	p
M7 (vs. M5)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience + Familiarity With the Band	194	213	.491	.649	2.59 (1)	.108
M8 (vs. M5)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience + Active Musical Engagement	192	211	.509	.649	0.78 (1)	.379
M9 (vs. M5)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience + Active Musical Engagement + Audience (vs. Band) × Active Musical Engagement	193	214	.522	.671	0.43 (2)	.808
M10 (vs. M5)	Social Connection ~ Audience (vs. Band) + Movement Entrainment + Positive Affect + Familiarity With the Audience + Age	194	212	.499	.649	2.00 (1)	.158

Note. Every model includes the random effect (1 | participant). The Akaike information criterion (AIC), Bayesian information criterion (BIC), marginal R^2 (i.e., variance explained by fixed effects only), and conditional R^2 (i.e., variance explained by fixed and random effects) are provided. χ^2 and p values refer to model comparisons to the model by the model stated in brackets using likelihood ratio tests. Null model: Social Connection ~ (1 | participant). The best fitting model is marked in bold letters.

Movement Entrainment. We then included the effect of Movement Entrainment. It improved model fit compared to M1 (see Table 5.5) and confirmed the results from the correl-

ation analysis: Movement Entrainment has a significant and positive main effect on Social Connection, $t(37) = 2.92$, $p = .006$ (see Table E.2 in the appendix).

We also tested for interaction between Audience (vs. Band) and Movement Entrainment and added it to the model (M3, see Table 5.5). The interaction was not significant and also did not lead to model improvement (see Table E.3 in the appendix), suggesting that the relationship between movement entrainment and social connection does not differ for band and audience.

Positive Affect. We then added Positive Affect to the model to test whether it influenced the feeling of social connection (M4), and it showed an improvement of the model fit (Table 5.5). Positive Affect had a significant positive effect on Social Connection, $t(36) = 4.18$, $p = <.001$ (see Table E.4 in the appendix).

Familiarity With the Other Audience Members and With the Band. We also hypothesised that both familiarity with other people in the audience and familiarity with the band may lead to more social connection. To assess participants' familiarity with other audience members, we used the number of known individuals in the audience as a metric for familiarity, given that nearly all participants reported attending the concert with companions. Familiarity With the Audience revealed a positive effect on Social Connection, $t(35) = 3.33$, $p = .002$ (see Table E.5 in the appendix) and a significant improvement of the model fit (M5, Table 5.5). The interaction among Audience (vs. Band) and Familiarity With the Audience was not significant (M6, Table 5.5) and did not lead to model improvement (see Table E.6 in the appendix), indicating that there is no difference in the relationship between being familiar with other audience members and social connection with the band and social connection with the other audience members.

Adding Familiarity With the Band to the model revealed no significant effect of this variable on Social Connection and it did not show significant improvement of the model fit (M7, Table 5.5, see also Table E.7 in the appendix). We had also asked if participants knew any members of the band personally, but, due to a lack of variability in the variable, we did not include it in the model as no effect was expected.

Active Musical Engagement. To analyse the effects of active musical engagement, a dimension of musical sophistication (Müllensiefen et al., 2014), we added it to the model. It showed no significant effect on social connection and no improvement of the model fit (M8, Table 5.5, see also Table E.8 in the appendix). We then added an interaction between Active Musical Engagement and the dummy variable Audience (vs. Band), which then revealed a significant negative effect of Active Musical Engagement on Social Connection, $t(34) = -2.24$, $p = .031$. The interaction showed a non-significant trend, $t(37) = 1.86$, $p = .071$ (Table E.9 in the appendix). The interaction plot indicated that active musical engagement may have

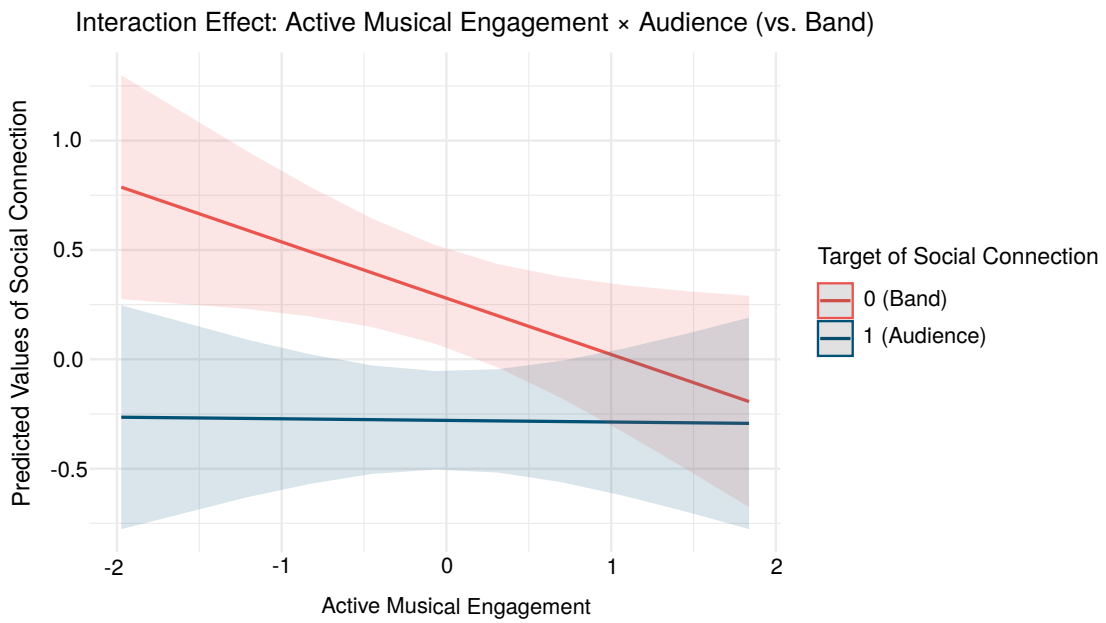


Figure 5.5: Interaction effect between Active Musical Engagement and the target of Social Connection (band vs. audience) on predicted values of the intensity of Social Connection.

negatively influenced social connection with the musicians, while leaving social connection with the audience unaffected (see Figure 5.5). However, it also did not improve the model fit significantly (M9, Table 5.5) and we ultimately excluded it from the final model.

Age. Adding the effect of Age to the model (M10, Table 5.5, see also Table E.10 in the appendix) revealed neither a significant effect nor improvement of the model fit.

Final Model. The main effects predicting Social Connection in the final model M5 are shown in Figure 5.6. Given the possibility of multicollinearity among the variables movement entrainment, positive affect, and familiarity with the audience of our final model with the best model fit M5, we examined the variance inflation factor (VIF). The VIF scores were 1.026, 1.036, and 1.020, indicating no evidence of multicollinearity (James et al., 2021). The final model contains significant effects for the target of social connection (audience vs. band): There was less social connection with the audience compared to the musicians. Movement entrainment had a significant and positive effect on the feeling of social connection. Also, positive affect measured after the concert had a positive and significant effect on social connection, as well as familiarity with other people in the audience. Being familiar with the band had no effect on a feeling of social connection.

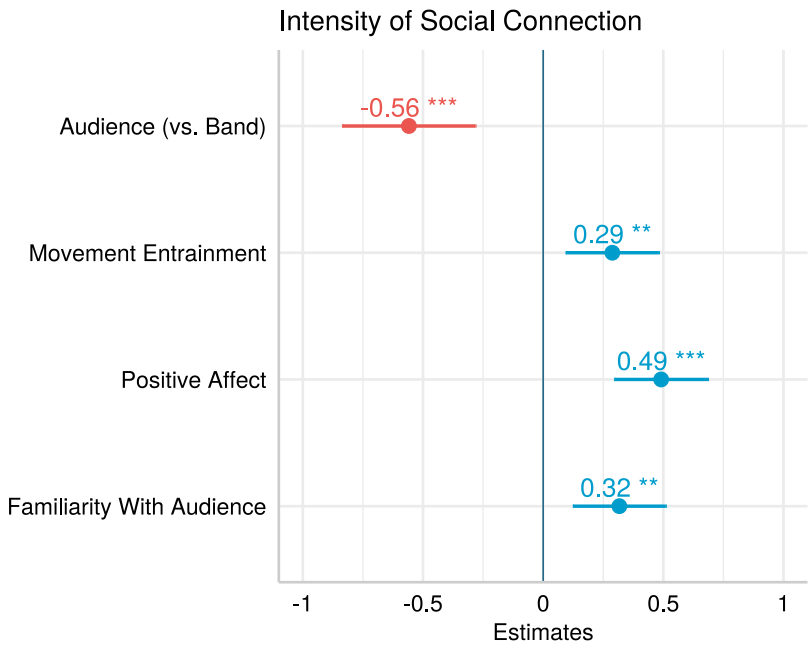


Figure 5.6: Main effects predicting Social Connection.

Note. Estimates from the multivariate hierarchical linear model predicting the intensity of Social Connection with Audience (vs. Band), Movement Entrainment, Positive Affect, and Familiarity With Other Audience Members as predictors. Negative estimates indicate lower social connection compared to the reference category, for the categorical predictor Audience (vs. Band); positive estimates indicate higher social connection per 1 SD increase in continuous, z-standardised predictors. Error bars represent ±1 standard error.

$^{**}p < .01$. $^{***}p < .001$.

5.2.4 Discussion

The focus of this experiment was to test the hypothesis that there is a positive relationship between joint movement to the music at a concert and pro-group thinking. The results provide partial support for the proposed relationship: four of the seven variables showed significant positive associations, while three were not statistically significant. Moreover, we found that the audience's social connection is stronger to the band than to the other audience members. In addition, we could identify effects of positive affect and familiarity with other people in the audience as further predictive variables of social connection.

The relation between synchronous movement and pro-group thinking has so far mainly been observed in laboratory studies (e.g., Hove and Risen, 2009; Tarr et al., 2016; Valdesolo et al., 2010; Wiltermuth and Heath, 2009). The present study has examined this relationship in an ecologically valid setting during a concert of an indie-pop band and demonstrated that the established link between synchronous movement and pro-group thinking can also be found in a setting in which people are free to move and dance, rather than performing finger tapping tasks, rocking, or moving cups in highly controlled laboratory settings. It is therefore a valuable contribution to the field of concert research and continues the efforts by Tarr et al. (2016), who studied the effects of synchronous dancing of small groups in a silent disco paradigm.

Concerning pro-group thinking towards the band, movement entrainment and the participants' social connection with the musicians correlated positively and significantly, indicating that moving to the music played by the musicians and feeling connected to the musicians are related. As it is likely that the musicians also moved in time with the music they were playing, this finding can be explained with synchrony effects. However, the measurement of closeness or inclusion of the band with the participants' self with an adapted version of the IOS Scale (Aron et al., 1992) was not significant. Aron et al. (1992) refer to their IOS Scale as a tool to measure the overlap of oneself with somebody else, a perceived closeness or sense of being interconnected with another, particularly in close relationships. Therefore, it is possible that this tool is not suitable to assess such a fleeting state of connection with the musicians. Although this measuring instrument has already been used by previous studies in combination with an explicit measure of social connection, these publications never reflected on the difference between IOS and explicit social connection, nor do the publications report any details of their measurement results or whether they also found a difference between the two (Onderdijk et al., 2021; Tarr et al., 2016). In our case, the two variables IOS_Band and Connection_Band were highly correlated (see Figure 5.4).

Regarding pro-group thinking towards the other audience members, we found significant and positive relationships between movement entrainment and inclusion of the other audi-

ence members in the self, social connection, and similarity. This finding largely replicates and expands the results of many laboratory studies reporting effects of joint movement and pro-group thinking (e.g., Hove and Risen, 2009; Tarr et al., 2016; Valdesolo et al., 2010; Wiltermuth and Heath, 2009). The correlations between movement entrainment and likeability as well as between movement entrainment and trust did not have statistical significance.

We aimed to explore the relation between movement entrainment and social connection further, and also wanted to include potential influencing variables. Therefore, we calculated a multivariate hierarchical linear model to explain general social connection. The significant negative effect of the dummy variable audience (vs. band) revealed that participants' felt social connection to the band was stronger than to the other audience members. This replicates findings by Swarbrick and Vuoskoski (2023) who also found that audiences both in a live and a streaming concert felt more connected to the musicians than to the audience. Although the band was physically separated from the audience by the stage and far away, particularly for participants in the back rows, the feeling of social connection to the band was stronger compared to the members of the audience in the immediate vicinity of the participants. This can be explained in several ways. First, as the band is performing on stage, it is the focus of the audience's attention. There are spotlights on the musicians, and they are playing and singing facing the audience and interacting with the audience during and between the songs. For many people in the audience, the main act may be the reason why they attended this concert in the first place, and they potentially identified as fans of the band, which may also explain the stronger social connection (Frith, 1996). Second, concerning movement entrainment, the band rather than the audience can be seen as the source of the external stimulus, with which the participants were synchronising. While playing, the band moved in time to the music, serving as an additional, visual stimulus, which can foster coordinated movement (Demos et al., 2012) and possibly lead to an increased feeling of social connection.

In the model, as already suggested by the correlation analysis, we identified movement entrainment as a significant predictor of social connection. The participants may have perceived their movement entrainment to the music as a coordinated movement with both the musicians and fellow audience members. This shared movement could have fostered a heightened sense of social connection with the group, encompassing both the band and the rest of the audience. Our findings do not indicate a significant interaction effect between the target of social connection – whether with the audience or with the band – and movement entrainment. This suggests that the association between movement entrainment and perceived social connection functions similarly, regardless of whether the reference point is the audience or the band. Movement entrainment appears to contribute to a sense of social connection in a comparable manner across both the audience and the band, rather than exhibiting a differential effect based on the primary social target.

Further, our results provide evidence that positive affect serves as a predictor of social connection. This finding stands in contrast to the conclusions drawn by Tarr et al. (2016), who suggest a dissociation between positive affect and social closeness. Their argumentation is based on observations from a silent disco experiment, in which participants exhibited increased positive affect following a dance activity, irrespective of whether they moved synchronously with others or not. This interpretation implies that the elevation in mood was independent of shared movement patterns. This is a distinct possibility; nevertheless, it does not permit conclusions to be drawn about the relationship between positive affect and social closeness. In a more nuanced manner, but pointing in a similar direction, Wiltermuth and Heath (2009) report that, though synchronous movement led to more cooperative behaviour, participants did not report being happier after synchronous movement conditions compared to asynchronous ones. The authors conclude that cooperation can be fostered by synchrony, even if positive emotions are not generated. However, our findings demonstrate a direct relationship between positive affect and perceived social connection, suggesting that affective states are associated with social connection, even if the mechanism is not strictly tied to movement synchrony. In light of this, a more plausible interpretation is that positive affect is not detached from feelings of social connection, but that moving to music or with others generally triggers positive affect – regardless of whether the movements are synchronised or matched (e.g., Hove & Risen, 2009; Lumsden et al., 2014; Mogan et al., 2017). This also implies that positive affect is rather shaped by broader social and contextual factors. Our findings from section 5.1.3 indicate a similar pattern: here, positive activation was a predictor for the Solidarity dimension of the SECS. Moreover, although they focused on longer-term effects, our findings align with those of Taylor et al. (2020) who demonstrated that individuals experiencing positive emotions tend to report greater social connection. Our finding underscores the complex interplay between emotional states and the feeling of social connection, highlighting how positive affect may foster social connection.

The finding that being familiar with other people in the audience had a positive effect on the feeling of social connection replicated findings by Onderdijk et al. (2021) and the previous study in section 5.1. As the interaction among the audience (vs. band) and familiarity with other audience members was not significant, this suggests no difference in the relationships between knowing other attendees and feeling connected to the band or to the audience. It is likely that those who already knew others in the crowd experienced a generally heightened sense of social connection, which may have reinforced their overall connection with both the musicians and the rest of the audience. Even though Swarbrick and Vuoskoski (2023) found that being a fan or family member leads to a feeling of increased social connection to the musicians, our results revealed that stated familiarity with the band had no significant effect on social connection in our model, which could be due to a ceiling effect, as more than 80% of

the participants reported that they were slightly or very familiar with the band. Additionally, knowing the band may not create as strong a bond as being a fan or family member, which could result in a weaker sense of social connection.

The effect of active musical engagement on social connection could not be determined with certainty. Although prior musical experience is often thought to enhance engagement with live performances, our findings suggest that it does not necessarily strengthen social connection with the musicians. One possible reason is that individuals with musical expertise may adopt a more analytical perspective, focusing on technical aspects rather than forming a bond with the performers. Additionally, they may identify more with the role of a musician rather than an audience member, which can lead to a critical comparison with the musicians rather than a passive immersion. This professional or trained perspective can create a subtle sense of detachment, reducing the feeling of social connection.

We also found no effect of age on the feeling of social connection, which may be attributable to the narrower age range and generally lower average age in our sample compared to the study by O'Neill and Egermann (2022). Moreover, their study identified two distinct groups within the audience of contemporary classical music concerts (music students and fee-paying public audience members), whereas the audience of our indie-pop concert setting may have been more homogeneous, potentially influencing the absence of age-related effects.

Our final model identified the dummy variable audience (vs. band) as the most influential factor affecting the general intensity of social connection experienced by concert attendees. Apart from the dummy variable, our model suggests that the positive affective state of individuals has the strongest influence on their perceived social connection with others. Additionally, both movement entrainment and familiarity with fellow audience members demonstrate almost similarly strong effects, indicating that movement entrainment and pre-existing social ties play a crucial role in shaping the overall experience of social connection during live performances. For the first time in an ecologically valid concert study in which the audience was free to move around and dance, we were able to identify such distinct relationships between movement entrainment and social connection.

However, due to the design of our study, we cannot assume causality. It is also possible that individuals moved to the music because they felt socially connected. Feeling connected may have made participants feel comfortable and want to move to the music with the other people. This leads to the limitations of the present study. As we only asked one question about general feelings of connection with the audience, this measure was relatively imprecise. It did not distinguish between people who stood close to participants, strangers or familiar people. As with the SECS, we do not know in relation to whom the people answered in the questionnaire. Additionally, due to the nature of our measurement method of audience movement, we were also unable to determine the precise locations of audience mem-

bers within the concert hall. To maintain ecological validity, attendees were allowed to move freely throughout the venue. We also did not ask after the concert where they stood during the performance. Therefore, we cannot ascertain whether a participant stood near the stage or further away, such as the back of the venue. However, the spot (or spots) from which participants observed the concert could have influenced their sense of social connection with the musicians and the other audience members. Greater visibility and spatial proximity likely play a role in forming this connection.

Moreover, we could not track which audience members were standing near one another at the concert or whether they actively interacted or danced together. For instance, a mosh pit formed during one song, and it would be valuable to identify which participants engaged in this collective movement and which did not, as such interactions within the audience may also have contributed to variations in the feeling of social connection. Various other measurement techniques can accurately determine the precise location of subjects, including motion capture systems. However, these are limited with large numbers of people and can require greater restrictions on the subjects. With our method, we were able to measure movement entrainment of many people at a concert with more than 300 people in the audience under ecologically valid conditions.

Further, it is possible that additional factors that were not included in our analysis contribute to a feeling of social connection. There is evidence that trait empathy and empathic concern can be predictors of social connection (Onderdijk et al., 2021; Swarbrick & Vuoskoski, 2023; Swarbrick et al., 2021). Empathic concern is also associated with prosocial and altruistic behaviour (FeldmanHall et al., 2015) and has been found to reduce generalised prejudice (Levin et al., 2016), which also suggests a tendency towards social connection. Since empathic concern has been linked to the extent of spontaneous body movement elicited by electronic dance music (Zelechowska et al., 2020), similar to other personality traits (Luck et al., 2010), it is possible that both empathy and further characteristics influenced movement entrainment, which, in turn, mediated the relationship between empathy and social connection. However, to ensure high completion rates and minimise respondent fatigue, we kept the questionnaire as concise as possible and did not include measures of empathy and further variables, as it would have extended the survey length, potentially reducing data quality and participant engagement. In follow-up studies, these personal characteristics should be considered.

This study is the first to investigate the relationship between movement entrainment and pro-group thinking in an ecologically valid concert setting in which the audience was also free to move and dance. By investigating further effects on the sense of social connection with the other people attending the concert as well as the musicians, we were able to expand the knowledge about the phenomenon of social connection to other people in concert contexts.

In light of research supporting the hypothesis that one of the main functions of music is to promote group solidarity and social cohesion through synchronised movement (Freeman, 2001; Huron, 2001), and that this capacity may represent an evolutionary adaptation (e.g., Savage et al., 2021), our findings provide empirical support for this idea during a live concert. Specifically, we demonstrate that movement entrainment is associated with enhanced pro-group thinking at live concerts, suggesting that music continues to play a fundamental role in uniting people through shared movement and collective experience. This finding may also help to explain why individuals who attend concerts more frequently exhibit higher levels of pro-social behavior (Polzella & Forbis, 2014).

6 General Discussion

This thesis investigated movement entrainment, social concert experience, and the relationship between the two, across different ecologically valid concert settings. The role of the concert format, specifically standing compared to sitting, was also examined in relation to both movement entrainment as well as general and social concert experience. Therefore, we collected three concert datasets: Using Concert Dataset 1, we tested and validated a method to measure movement entrainment in an ecologically valid concert setting. Based on Concert Dataset 2, we investigated contributing factors to movement entrainment. Using a seated and an unseated concert version, we were able to examine the effect of the concert format on movement entrainment as well as on general and social audience experience. Using Concert Dataset 3, we investigated the relationship between movement entrainment and social audience experience, as well as additional contributing factors.

6.1 Main Findings

Figure 6.1 presents a summary of the main findings of this thesis.

As movement entrainment has usually been assessed using small sample sizes or settings in which participants were seated, we employed an audience response system to collect movement data in Concert Dataset 1. We used small, lightweight measuring devices that participants wore with a band around their torsos and arms. With the devices, participants were able to move freely in the building in which the rock concert took place, to ensure ecological validity. We defined movement entrainment as the extent to which people moved their body to the beat of the songs performed during the concert. We found significant movement entrainment to the beat of the music. The intensity of movement entrainment was also related to participants' self-reported desire to move and dance during the concert, which also confirmed the validity of our measurement of movement entrainment. As this method of measuring movement entrainment yielded reliable results, we employed it in subsequent experiments to further examine movement entrainment in ecologically valid concert settings and to relate it to general and social concert experience.

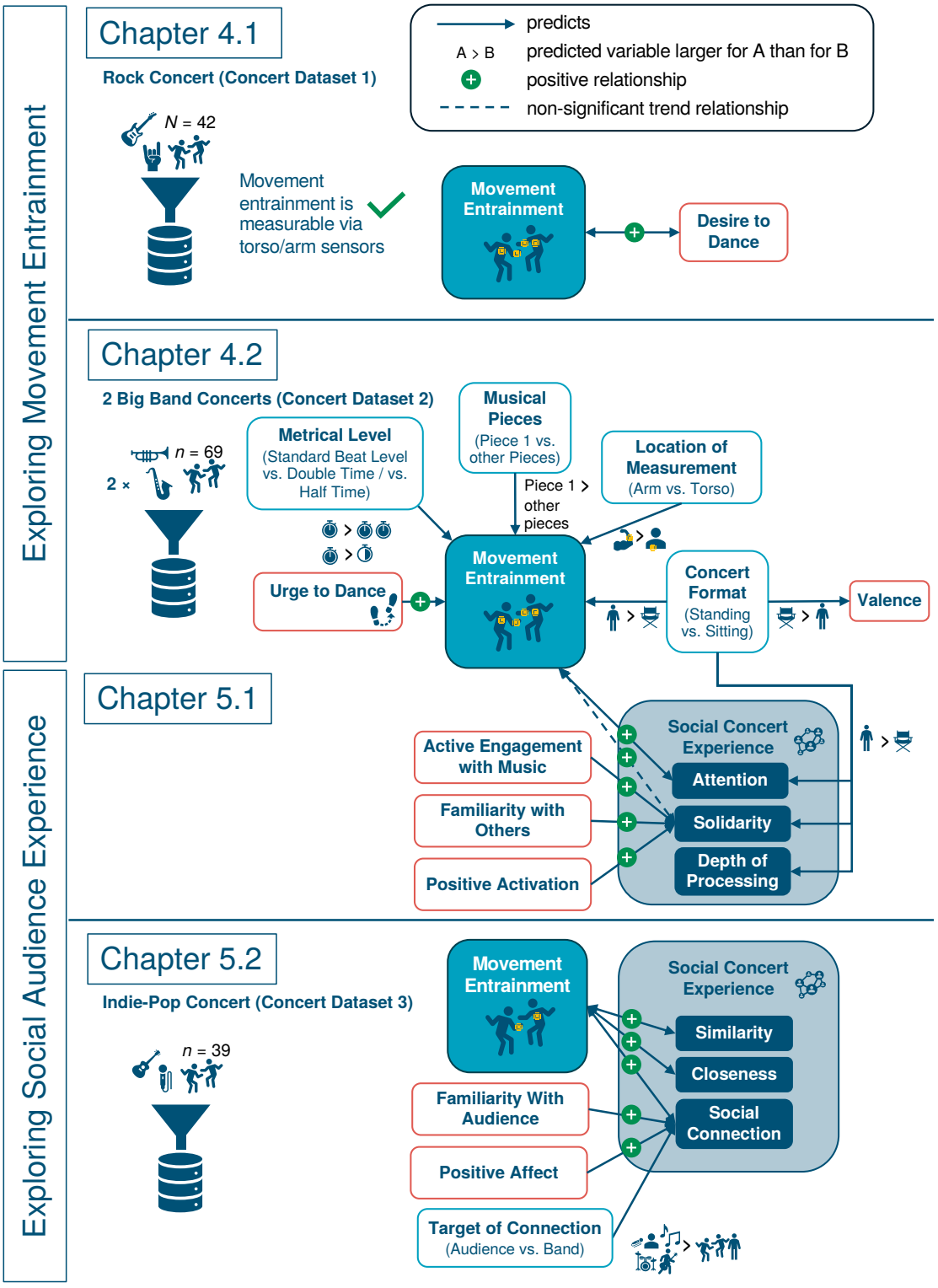


Figure 6.1: Overview of the main findings of this thesis.

Building on the framework by Scherer and Zentner (2001) that emotional reactions to music result from the music itself, the context, and the listener, we examined how these factors contribute to movement entrainment. We collected Concert Dataset 2 during two big band concerts with the same programme. The only difference was that one concert had seating while the other did not. We estimated several consecutive hierarchical linear models to identify factors predicting movement entrainment. As we measured movement entrainment on two locations of the body (arm and torso) and on several beat levels (standard beat level BPM, half-time, and double-time beat level), we additionally included factors of measurement in our analysis. The factors of measurement, the musical pieces, the concert format (standing vs. sitting), and the personal characteristic of the urge to dance was shown to contribute significantly to movement entrainment. We measured more movement entrainment at the arm compared to the torso, and most movement entrainment on the standard beat level compared to the half-time and double-time level. Further, the highest level of movement entrainment occurred during the first piece compared to the other pieces. Regarding the concert format, there was more movement entrainment during the unseated than the seated version. Finally, the positive and significant main effect of the personal characteristic of the urge to dance on movement entrainment indicated a positive relationship between the two.

To investigate the effects of the concert format on general and social concert experience, we reanalysed Concert Dataset 2. Concerning the general evaluation of the concert, as well as positive and negative activation after the concert, the concert format had no significant effects. However, the format standing (vs. sitting) had a significant negative effect on valence after the concert, indicating lower levels of satisfaction and content after the unseated concert. With positive effects of the concert format standing (vs. sitting) on the dimensions of Attention, Solidarity, and Depth of Processing of the Social Experience of a Concert Scale (O'Neill & Egermann, 2022), we found that the standing concert was the more social experience compared to the seated version. A structural equation model revealed that familiarity with other audience members, active engagement with music, as well as positive activation after the concert contribute to the dimension of Solidarity. The correlation between movement entrainment and solidarity revealed a non-significant trend, despite the expectation that the dimension of Solidarity would best reflect the positive effects of joint movement.

A follow-up study was conducted in a different concert context: an unseated, standing-only indie-pop concert, during which we anticipated more movement entrainment. We employed revised measurement instruments for pro-group thinking, in line with previous studies on this phenomenon, to better capture the dynamics of social audience experience. Concert Dataset 3 revealed that audience movement entrainment is positively and significantly correlated with social connection, both towards the audience members and the musicians.

The results also indicated a correlation between movement entrainment and perceived similarity and closeness to other audience members. The relationship between movement entrainment and likeability of the other audience members and trust in them was not significant, similar to the relationship between movement entrainment and perceived closeness to the musicians. With a multivariate hierarchical linear model we further investigated the contributing factors to social connection. Results revealed that the target of social connection (audience vs. band) had a significant negative effect on social connection, indicating that the social connection towards the band was higher compared to the audience. Additionally, movement entrainment, positive affect, and familiarity with the audience were positively and significantly related to the intensity of social connection.

6.2 Discussion

This thesis has made a significant contribution to the understanding of live music experiences by investigating audience movement entrainment, social concert experience – including pro-group thinking and specifically social connection – and their interplay, as well as the role of concert format, in ecologically valid concert settings. Through an exploratory, multi-method approach, the study advances both methodological and theoretical frontiers in the field of music psychology and concert research.

A key methodological innovation lies in the use of small, wearable accelerometers of an audience response system to measure movement entrainment in real-world rock, big band, and pop concerts. This approach enabled the reliable assessment of movement to the music across large groups of participants without restricting their concert attendance. The method is robust under varying spatial and lighting conditions, and could theoretically be used anywhere, even in open-air settings. Crucially, this thesis presents the first empirical investigation of movement entrainment, its contributing factors, and its relation to social concert experience in an ecologically valid concert setting in which the audience was also free to move around and even dance, demonstrating that movement during concerts can be measured with high ecological validity. The positive reception from concertgoers, many of whom expressed interest in the research and willingly and curiously wore the devices, further underscores the feasibility and acceptability of this method. As has already been demonstrated in the study by Swarbrick and Vuoskoski (2023), using acceleration data from participants' smartphones would make this method easy to apply to an unlimited number of participants.

Further, the Social Experience of a Concert Scale (O'Neill & Egermann, 2022) was successfully applied for the first time outside of Western classical concerts, demonstrating its cross-contextual validity despite the need to exclude one item due to translation challenges. This supports its potential as a versatile tool for future research.

To measure the pro-group outcomes of social concert experience more precisely, we employed a set of items adapted from previous studies (Aron et al., 1992; Hove & Risen, 2009; Tarr et al., 2016; Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009). These items – social connection, inclusion of the other in the self or closeness, trust, perceived similarity, and likeability – have been used in prior research to measure effects of synchronous movements. This collection of items represents a long-standing methodological gap: the lack of conceptual clarity and standardised measurement in the assessment of concepts such as social bonding and pro-group thinking, including social connection, not only in the context of concerts.

In addition to methodological aspects, a major contribution of this thesis to concert research is the first direct comparison of a standing versus a seated concert format in a live music context. The findings indicate that the standing concert fostered significantly higher levels of movement entrainment and was perceived as a generally more social experience by the audience compared to the seated concert. While satisfaction and content ratings were lower after the standing concert – possibly due to physical fatigue or genre-specific expectations – this does not diminish the importance of standing and freedom in movement in shaping the social experience. This finding has practical relevance for concert organisers, particularly in genres, in which standing is common but not standard. Importantly, this finding aligns with the embodied music cognition framework, which emphasises the role of the body in shaping music perception (Leman, 2008). A concert is not merely passive music listening, but rather active participation in the experience of music.

The results from chapter 5 are important for research on joint movement and pro-group thinking outcomes, challenging the notion that positive affect is disconnected from social closeness (Tarr et al., 2016). Instead, positive affect was found to be positively and significantly associated with social concert experience, particularly feelings of solidarity and social connection.

Additionally, this thesis is the first to demonstrate in a real-world concert setting, in which the audience was free to move and dance, that the positive relationship between movement entrainment and pro-group thinking is not confined to controlled laboratory environments. While previous research has primarily documented these effects in laboratory contexts involving instructed active participation or instructed dance in small groups, this study demonstrates that there is a link between audience members' free movement in time with the music and pro-group thinking during a live concert. This suggests that the power of music to foster group cohesion extends beyond active collaboration and is also activated through shared, embodied experiences concerts. The positive correlation between joint movement to the music and social connection, both in relation to fellow audience members and to the performers, supports the hypothesis that music functions as a social bonding agent through synchronised

action. These findings align with evolutionary theories of music as a mechanism for group cohesion (Huron, 2001; Savage et al., 2021) and underscore the idea that the collective experience of a concert can generate profound social effects. However, we cannot establish a definite causal relationship between movement entrainment and pro-group thinking.

This uncertainty was further highlighted by the non-significant trend relationship between movement entrainment and solidarity in Concert Dataset 2, despite the standing concert being perceived as the more social experience. A mediation analysis testing whether movement entrainment mediated the effect of concert format on attention also yielded no significant results. To address this, we conducted Concert Dataset 3 in a different concert context – a standing-only indie-pop concert during which we would expect more movement entrainment – using revised measurement instruments for pro-group thinking. However, to preserve the ecological validity of our exploratory approach, we chose not to manipulate or control for movement entrainment, which limits our ability to draw causal conclusions.

As discussed in the background chapter of this thesis, the emergence of social connection and pro-group thinking in concert settings may be the result of multiple interrelated factors. While synchronous movement can play a role, it is unlikely to be the only factor. Other mechanisms, such as perceived similarity and a shared sense of group identity for reasons other than shared movement, shared attention, the collective experience of emotions or physiological responses, may also contribute to the positive feelings towards others and connection, but are also likely to be related to joint movement. Therefore, it is plausible that the pro-group effects during concerts arise from the complex interplay of joint movement and broader socio-cognitive processes rather than movement entrainment alone. The finding that positive affect and familiarity with other audience members were positively and significantly associated with solidarity and perceived social connection provides clear empirical support for this multifactorial perspective.

6.3 Limitations

Several limitations concerning the measurement methods should be acknowledged. As previously mentioned in chapters 4 and 5, the measurement of movement entrainment was based on relative movement rather than absolute position, and participants were free to move throughout the concert space. While this approach ensured high ecological validity, it also limits the precision of movement assessment and prevents conclusions about spatial coordination or interpersonal synchrony.

Additionally, the assessment of general and social concert experience relied on post-concert self-reports, which does not capture the dynamic, moment-to-moment changes in affect and connection throughout a concert. This methodological choice was made to pre-

serve the ecological validity of the concert experience, as frequent interruptions during the concert with questionnaires would have disrupted the natural flow of the event. In this context, a trade-off exists between data quality and the authenticity of the experience: while more frequent or real-time measurements may yield more detailed data, they risk altering the very phenomenon under investigation.

Furthermore, the target of social audience experience, whether fellow audience members or the musicians, was not clearly specified in the questionnaire. As a result, participants may have interpreted the items in different ways: some may have focused on the people they knew, others on those they were with, and still others on the performers as a collective group or the lead singer only. This ambiguity in the target of social audience experience limits the interpretability of the results. The study does also not capture the musicians' perspective, which could provide valuable insights into the reciprocal nature of the concert experience.

When examining the general concert experience as an overall evaluation of the event, it became evident that all four concerts were rated relatively positively. These ceiling effects hinder the ability to detect meaningful associations between concert evaluation and other variables such as movement entrainment. While it is plausible that attendees at paid concerts often choose to attend based on prior expectations of enjoyment, particularly due to familiarity with the artist or genre, this explanation does not fully account for the high ratings observed in three of the four concerts, all of which were free of charge. These free events took place within a university context, and attendance was likely dominated by friends, family members, or individuals already familiar with the performing ensemble. Consequently, the sample may have been inherently biased towards positive evaluations.

It has already been discussed that, due to the exploratory design of the study, causal relationships cannot be established. For the relationship between movement entrainment and pro-group thinking, including social connection, a bidirectional interpretation is possible: synchronised movement may foster pro-group thinking, while the feeling of social connection, trust and similarity may also foster a sense of ease, encouraging greater engagement with the music and freer movement without inhibition.

Moreover, while we found a positive relationship between movement entrainment and pro-group thinking, and a higher degree of social concert experience after the standing concert compared to the seated version, it remains unclear to what extent such positive social effects endure beyond the event. True social bonding, characterised by sustained interaction, mutual trust, and long-term affiliation, likely requires more than a single shared experience. The fleeting nature of the concert setting may foster temporary feelings of closeness, but it may not be sufficient to establish lasting social ties. However, the concert context offers the opportunity to establish or deepen social relationships.

Finally, while this study provides valuable insights into movement entrainment and social audience experience during live concerts, it is important to recognise that only a limited number of contributing factors could be considered. The concert experience is inherently complex, shaped by the music and its performance, the context, including cultural differences and situational dynamics, as well as individual differences. Additionally, the findings are based on a WEIRD sample (Western, Educated, Industrialised, Rich, Democratic; Henrich et al., 2010), limiting the generalisability to other genres, cultural contexts, or audience demographics. This highlights possible directions for future studies.

6.4 Outlook

Future research should build on the findings of this thesis by addressing its limitations and exploring new avenues to understand the dynamics of live music experiences. First, the role of personal characteristics, such as trait empathy, personality traits, and individual differences in movement behaviour as well as social audience experience, should be investigated in greater depth. The generalisability of the findings should also be tested across diverse musical genres, cultural traditions, and concert formats. To increase the range of responses concerning the general evaluation of the concert and to make future studies more sensitive to this variable, it would be beneficial to analyse audiences in contexts, in which musical preferences are less predictable. For instance, music festivals featuring unknown or unfamiliar bands could provide a more diverse sample, including individuals who may not automatically expect to enjoy the performance. In such settings, the contrast between high and low enjoyment levels would be more pronounced, enabling a more nuanced analysis of how movement entrainment as well as the concert format relates to the evaluation of the concert.

Future research also needs a more comprehensive and multi-method approach to understand the dynamics of movement entrainment and social audience experience in live music settings. Notably, to enhance comparability across studies, standardised terminology and measurement of social audience experience and pro-group thinking – using validated instruments such as the Inclusion of the Other in the Self (IOS) Scale (Aron et al., 1992) as part of a multi-dimensional pro-group thinking scale – need to be developed and validated. Furthermore, integrating observational and behavioural real-time measures, such as interpersonal synchrony and coordinated movements, hand gestures, eye contact and cooperative actions, attention via eye-tracking, facial expression analysis or physiological sensors would provide a more comprehensive picture of the relationship between concert attendance and social concert experience. Future studies should also investigate whether these fleeting connections can be transferred and how repeated exposure to live music can influence, for example, well-being over time by fostering a sense of social connection. While this thesis has examined aspects

that relate positively to social experience exclusively, it would also be interesting to investigate factors that inhibit these processes. Thus, also the musicians' perspective – how they perceive audience movement and engagement, how they respond physically, and whether they experience social bonding – would provide a more complete, two-way understanding of the concert as a shared experience.

Finally, distinct causal relationships between movement entrainment and pro-group thinking remain untested. While Concert Dataset 2 includes a quasi-experimental design limiting bodily movement (standing compared to sitting), future research could employ further experimental manipulations, such as the band encouraging the audience to move along with the music, or virtual reality environments, to establish causality.

6.5 Final Conclusions

This study demonstrates that audience movement entrainment is associated with social experience in live music settings. It emphasises the importance of physical engagement and freedom of movement, particularly joint movement to the beat, in shaping the collective experience. The concert is not merely a performance, but an embodied, social event during which the listener and their body, the music and the performers, the other people attending and the context co-create and contribute to a moment of shared experience. Given that social connection is a key determinant of psychological well-being (Baumeister & Leary, 1995) and that people attend live music events precisely to experience a sense of belonging (S. C. Brown & Knox, 2017; Cannon & Greasley, 2021), these findings suggest that concert experiences may contribute at least to a certain degree to individual and collective well-being, potentially strengthening the social and emotional benefits already known to be linked with music (e.g., Bernatzky & Kreutz, 2015).

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A Supplementary Material for Concert Dataset 1

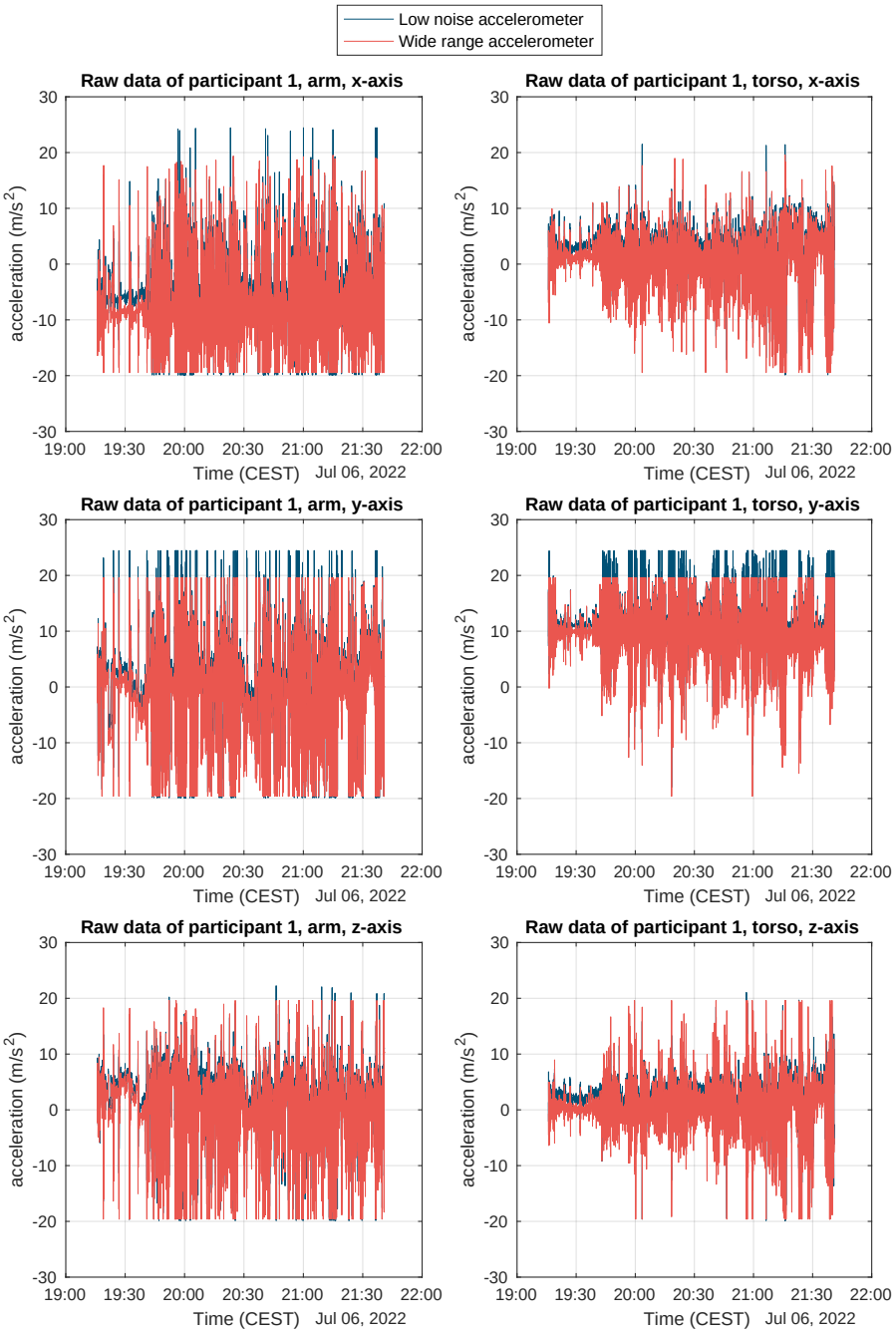


Figure A.1: Example raw data for the whole concert.

Note. Raw data of the low noise accelerometer and the wide range accelerometer of Participant 1 in Concert Dataset 1 for each location of measurement (arm and torso) and each axis (x-, y-, and z-axis). The lack of accelerometer calibration does not impact our analysis, as we are interested in movement frequency and relative amplitude, but not absolute acceleration values.

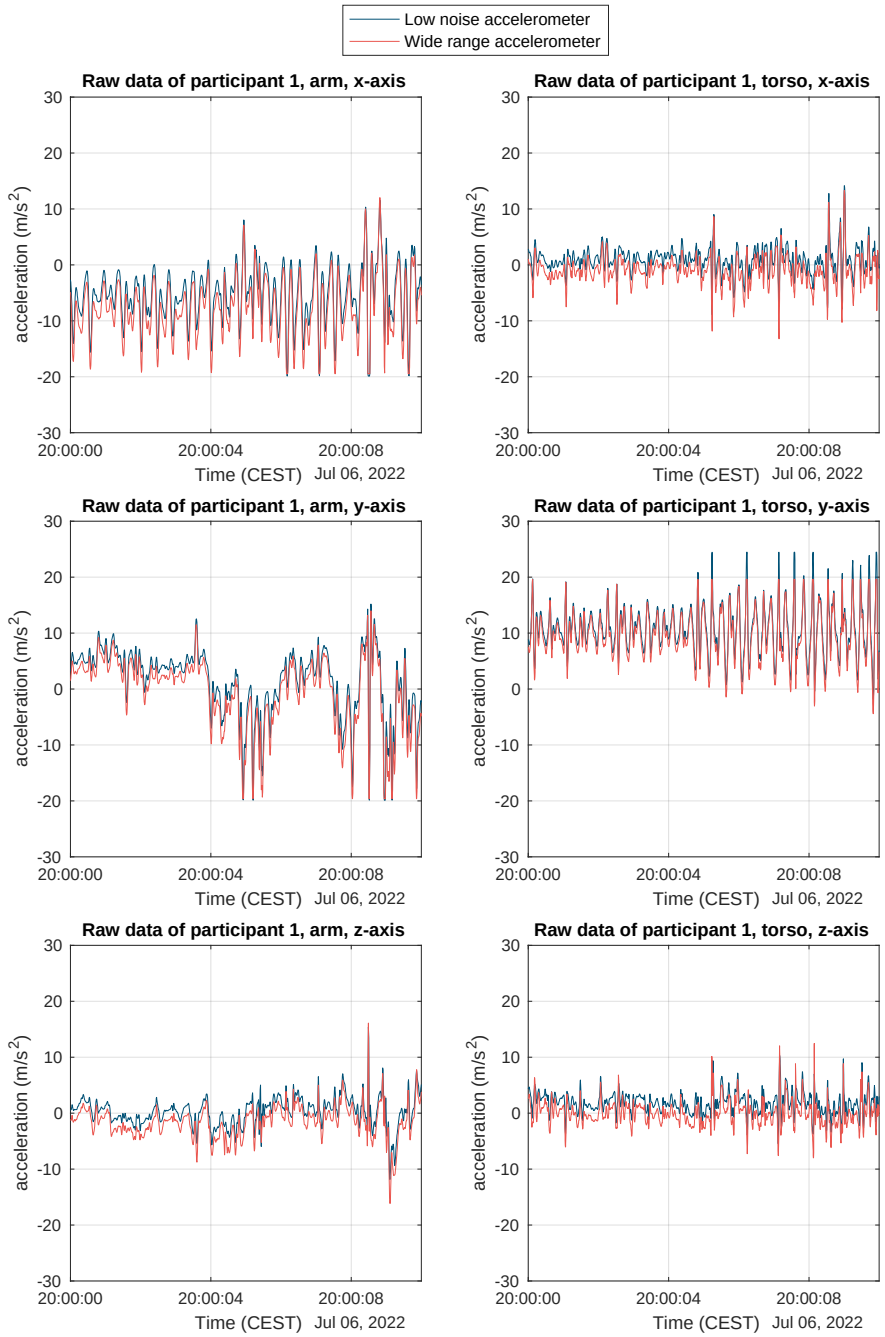


Figure A.2: Example raw data detail.

Note. Raw data of the low noise accelerometer and the wide range accelerometer of Participant 1 in Concert Dataset 1 for each location of measurement (arm and torso) and each axis (x-, y-, and z-axis) after interpolation. Detailed view of a 10-second time window.

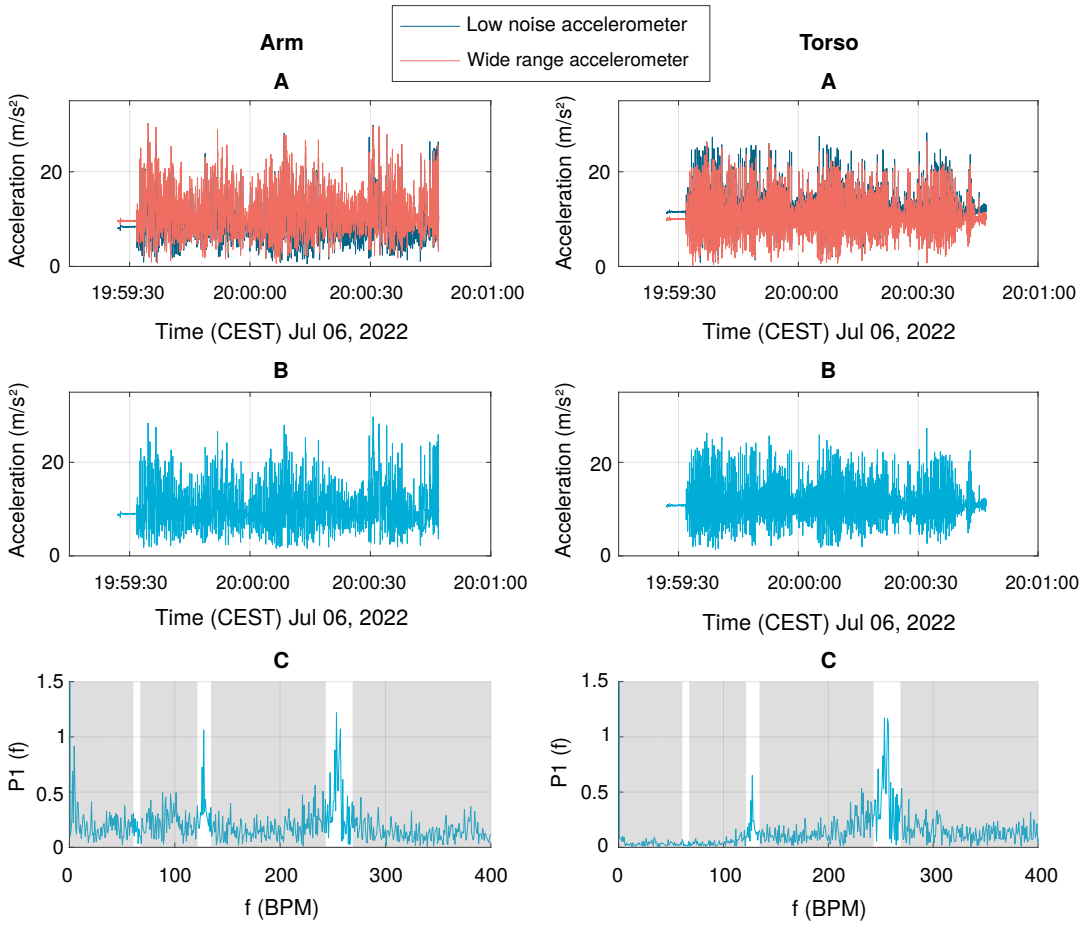


Figure A.3: Example workflow of the analysis.

Note. **A**: Combined x-, y-, and z-axis (after calculating the square root of the sum of the squares) of participant 1 in Concert Dataset 1 for each location of measurement (arm and torso) and both the low noise accelerometer and the wide range accelerometer during piece 11. **B**: Combined x-, y-, and z-axis (after calculating the square root of the sum of the squares) and combined data of the low noise and the wide range accelerometer of participant 1 in Concert Dataset 1 for each location of measurement (arm and torso) during piece 11. **C**: Single-sided amplitude spectrum of the frequencies of the acceleration data of participant 1 in Concert Dataset 1 for each location of measurement (arm and torso) during piece 11. The BPM value of the piece was 128. The areas around the half-time level (64 BPM), standard beat level (128 BPM) and double-time level (256 BPM) with a tolerance range of ±5% are highlighted in white in the background.

B Questionnaires for Concert Dataset 1

B.1 Pre-Concert Questionnaire

technische universität dortmund

Fakultät für Kunst- und Sportwissenschaften
Institut für Musik
und Musikwissenschaft

DSML
Dortmund Systematic Musicology Lab

– Studie *Live-Erleben im Rockkonzert* –

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Eingangsfragebogen „Live-Erleben im Rockkonzert“

Liebe:r Konzertbesucher:in,
vielen Dank für die Teilnahme an diesem Experiment. Dieses Forschungsprojekt untersucht das Erleben eines Rockkonzerts. Darum ist Deine Meinung für uns wichtig. Bitte fülle den Fragebogen in Ruhe aus. Alle Daten sind anonymisiert. Bei Fragen wende Dich bitte an das Team. Vielen Dank für Deine Mitarbeit.

Code:
Bitte trage hier Dein Codewort ein.

Die ersten beiden Buchstaben des Vornamens Deiner Mutter: ___ ___
Den Geburtstag Deiner Mutter (nur der Tag): ___ ___
Deinen eigenen Geburtstag (nur der Tag): ___ ___

→ **Daraus ergibt sich Dein Codewort: ___ ___ ___ ___ ___ ___**

Wie fühlst Du Dich hier und jetzt?
Bitte gib an, wo Du Dich jeweils zwischen den beiden Eigenschaftspaaren einordnen würdest.
Bitte setze in jeder Zeile ein Kreuz.

	(3) sehr	(2)	(1)	(0) unentschieden	(1)	(2)	(3) sehr	
besorgt	☐	☐	☐	☐	☐	☐	☐	sorgenfrei
gestresst	☐	☐	☐	☐	☐	☐	☐	entspannt
zufrieden	☐	☐	☐	☐	☐	☐	☐	unzufrieden
lustlos	☐	☐	☐	☐	☐	☐	☐	hoch motiviert
ruhig	☐	☐	☐	☐	☐	☐	☐	nervös
unglücklich	☐	☐	☐	☐	☐	☐	☐	glücklich
friedlich	☐	☐	☐	☐	☐	☐	☐	verärgert
begeistert	☐	☐	☐	☐	☐	☐	☐	gelangweilt
müde	☐	☐	☐	☐	☐	☐	☐	hellwach
energiegeladen	☐	☐	☐	☐	☐	☐	☐	energielos

bitte wenden (die Seiten sind doppelseitig bedruckt)

Wie häufig hörst Du die folgenden Musikrichtungen (gemeint sind nur solche Situationen, in denen Du selbst bestimmen kannst, welche Musik Du hörst)?
Bitte setze in jeder Zeile ein Kreuz.

	nie	selten	ein paar Mal pro Monat	mehrmals pro Woche	täglich
Alternative	☐	☐	☐	☐	☐
Bluegrass	☐	☐	☐	☐	☐
Blues	☐	☐	☐	☐	☐
Klassische Musik	☐	☐	☐	☐	☐
Country	☐	☐	☐	☐	☐
Electronica/Dance	☐	☐	☐	☐	☐
Folk	☐	☐	☐	☐	☐
Funk	☐	☐	☐	☐	☐
Gospel	☐	☐	☐	☐	☐
Heavy Metal	☐	☐	☐	☐	☐
Weltmusik	☐	☐	☐	☐	☐
Jazz	☐	☐	☐	☐	☐
New Age	☐	☐	☐	☐	☐
Oldies	☐	☐	☐	☐	☐
Oper	☐	☐	☐	☐	☐
Pop	☐	☐	☐	☐	☐
Punk	☐	☐	☐	☐	☐
Rap/Hiphop	☐	☐	☐	☐	☐
Reggae	☐	☐	☐	☐	☐
Religiöse Musik	☐	☐	☐	☐	☐
Rock	☐	☐	☐	☐	☐
Soul/R&B	☐	☐	☐	☐	☐
Soundtracks/Film-musik	☐	☐	☐	☐	☐

Du wirst jetzt eine Reihe von Aussagen lesen, die jeweils bestimmte (verallgemeinerte) menschliche Eigenschaften oder Reaktionen beschreiben, die alle etwas mit Gefühlen zu tun haben. Bitte kreuze an, inwieweit diese Aussage auf Dich zutrifft. Vielleicht fällt Dir auch zu der einen oder anderen allgemeinen Beschreibung ein konkretes Erlebnis ein.
Es gibt dabei keine richtigen oder falschen Antworten.
Bitte setze in jeder Zeile ein Kreuz.

Trifft wie oft zu?	nie	selten	manch-mal	oft	immer
Ich empfinde warmherzige Gefühle für Leute, denen es weniger gut geht als mir.	☐	☐	☐	☐	☐
Die Gefühle einer Person in einem Roman kann ich mir sehr gut vorstellen.	☐	☐	☐	☐	☐
In Notfallsituationen fühle ich mich ängstlich und unbehaglich.	☐	☐	☐	☐	☐
Ich versuche bei einem Streit zuerst beide Seiten zu verstehen, bevor ich eine Entscheidung treffe.	☐	☐	☐	☐	☐
Wenn ich sehe, wie eine Person ausgenutzt wird, glaube ich, sie schützen zu müssen.	☐	☐	☐	☐	☐
Ich fühle mich hilflos, wenn ich inmitten einer sehr emotionsgeladenen Situation bin.	☐	☐	☐	☐	☐
Nachdem ich einen Film gesehen habe, fühle ich mich so, als ob ich eine der Personen aus diesem Film sei.	☐	☐	☐	☐	☐
In einer gespannten emotionalen Situation zu sein, macht mir Angst.	☐	☐	☐	☐	☐
Mich berühren Dinge sehr, auch wenn ich sie nur beobachte.	☐	☐	☐	☐	☐
Ich glaube, jedes Problem hat zwei Seiten und versuche deshalb beide zu berücksichtigen.	☐	☐	☐	☐	☐
Ich würde mich selbst als eine ziemlich weichherzige Person bezeichnen.	☐	☐	☐	☐	☐
Wenn ich einen guten Film sehe, kann ich mich sehr leicht in die Hauptperson hineinversetzen.	☐	☐	☐	☐	☐
In heiklen Situationen neige ich dazu, die Kontrolle über mich zu verlieren.	☐	☐	☐	☐	☐

bitte wenden (die Seiten sind doppelseitig bedruckt)

	nie	selten	manch-mal	oft	immer
Wenn mir das Verhalten einer anderen Person komisch vorkommt, versuche ich mich für eine Weile in ihre Lage zu versetzen.	☐	☐	☐	☐	☐
Wenn ich eine interessante Geschichte oder ein gutes Buch lese, versuche ich mir vorzustellen, wie ich mich fühlen würde, wenn mir die Ereignisse passieren würden.	☐	☐	☐	☐	☐
Bevor ich eine Person kritisiere, versuche ich mir vorzustellen, wie die Sache aus ihrer Sicht aussieht.	☐	☐	☐	☐	☐

Wie sehr stimmst Du den folgenden Aussagen zu?
Bitte setze in jeder Zeile ein Kreuz.

	stimme ganz und gar nicht zu	stimme nicht zu	stimme eher nicht zu	weder noch	stimme eher zu	stimme zu	stimme voll und ganz zu
Ich finde es leicht, neue Bewegungen zu erlernen.	☐	☐	☐	☐	☐	☐	☐
Ich mag es, vor anderen Leuten zu tanzen.	☐	☐	☐	☐	☐	☐	☐
Wenn ich ein tolles Musikstück höre, muss ich einfach anfangen zu tanzen.	☐	☐	☐	☐	☐	☐	☐
Wenn ich die Wahl hätte, würde ich mir lieber ein Theaterstück als eine Tanzaufführung angucken.	☐	☐	☐	☐	☐	☐	☐
Ich weiß viel über Tanz und Choreografie.	☐	☐	☐	☐	☐	☐	☐
Ich finde es leicht, meine Bewegungen zu kontrollieren.	☐	☐	☐	☐	☐	☐	☐
Ich wäre lieber ein:e gute:r Sänger:in als ein:e gute:r Tänzer:in.	☐	☐	☐	☐	☐	☐	☐

	stimme ganz und gar nicht zu	stimme nicht zu	stimme eher nicht zu	weder noch	stimme eher zu	stimme zu	stimme voll und ganz zu
Man muss mich normalerweise auf die Tanzfläche schleifen, weil ich nicht weiß, was ich tun soll.	☐	☐	☐	☐	☐	☐	☐
Ich bin mir meines Körpers und meiner Haltung bewusst.	☐	☐	☐	☐	☐	☐	☐
Ich bin gewillt zu reisen, um eine Tanzaufführung zu sehen oder an Tanzstunden teilzunehmen.	☐	☐	☐	☐	☐	☐	☐
Manchmal habe ich das Gefühl einfach tanzen zu müssen.	☐	☐	☐	☐	☐	☐	☐
Ich bin nicht sehr geschickt, wenn ich mich bewege.	☐	☐	☐	☐	☐	☐	☐
Ich finde Tanzen wirklich peinlich.	☐	☐	☐	☐	☐	☐	☐
Wenn ich mir Musik im Kopf vorstelle, will mein Körper anfangen sich zu bewegen.	☐	☐	☐	☐	☐	☐	☐
Mit anderen Leuten zu tanzen ist eine tolle Ausgehmöglichkeit, wenn man mich fragt.	☐	☐	☐	☐	☐	☐	☐
Ich finde es leicht, die Bewegungen von anderen zu lernen oder nachzumachen.	☐	☐	☐	☐	☐	☐	☐
Wenn mich jemand fragt, ob ich tanzen möchte, sage ich normalerweise ja.	☐	☐	☐	☐	☐	☐	☐
Ich verbringe nicht viel Zeit mit tanzbezogenen Aktivitäten.	☐	☐	☐	☐	☐	☐	☐
Ich mag es, Leuten beim Tanzen zuzugucken.	☐	☐	☐	☐	☐	☐	☐
Ich habe das Gefühl, als hätte ich zwei linke Füße.	☐	☐	☐	☐	☐	☐	☐

bitte wenden (die Seiten sind doppelseitig bedruckt)

	stimme ganz und gar nicht zu	stimme nicht zu	stimme eher nicht zu	weder noch	stimme eher zu	stimme zu	stimme voll und ganz zu
Wenn ich tanze, fühle ich mich besser.	☐	☐	☐	☐	☐	☐	☐
Ich würde lieber in eine Bar als in einen Club zu gehen, um nicht tanzen zu müssen.	☐	☐	☐	☐	☐	☐	☐
Ich habe … Jahre wöchentlich Tanzunterricht erhalten	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4–5	☐ 6–9	☐ 10 oder mehr
Wie oft siehst Du Dir Tanzaufführungen/-shows/ -videos im Fernsehen oder Internet an?	☐ so gut wie nie	☐ einmal im Jahr		☐ alle paar Monate	☐ einmal im Monat		☐ mehrmals im Monat
Ich würde meine Erfahrung mit Tanzen wie folgt einordnen:	☐ keine vorhanden	☐ Anfänger:in		☐ mittel	☐ fortgeschritten		☐ professionell
Ich hatte formales Training für einen bestimmten Tanzstil für…	☐ 0 Jahre	☐ 0,5 Jahre	☐ 1 Jahr	☐ 2 Jahre	☐ 3 Jahre	☐ 4–6 Jahre	☐ 7 oder mehr Jahre

---

Wie alt bist Du?

_____ Jahre

Welchem Geschlecht fühlst Du Dich zugehörig? Bitte wähle eine der folgenden Antworten:

☐ weiblich
☐ männlich
☐ anderes

Studierst Du?

☐ nein
☐ ja
Falls ja: Was studierst Du?

_____

Bist Du heute alleine oder in Begleitung gekommen?

- ☐ alleine
- ☐ in Begleitung

Welche Anzahl an Konzerten (Pop, Rock, Jazz, Klassik, Oper, etc.) hast Du als Zuhörer:in innerhalb der letzten 12 Monate besucht?

____ Konzerte

Wie viele davon waren Pop- oder Rockkonzerte?

____ Pop- und Rockkonzerte

Würdest Du Dich selbst als Musiker:in bezeichnen?

- ☐ ja
- ☐ nein

Geschafft – vielen Dank!
Jetzt kannst Du weiter zum Verkabeln. Dort kannst Du auch Deinen Fragebogen abgeben.
Viel Spaß beim Konzert!

B.2 Post-Concert Questionnaire

technische universität dortmund

DSML
Dortmund Systematic Musicology Lab

Fakultät für Kunst- und Sportwissenschaften
Institut für Musik
und Musikwissenschaft

– Studie *Live-Erleben im Rockkonzert* –

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Ausgangsfragebogen „Live-Erleben im Rockkonzert“

Liebe:r Konzertbesucher:in,
vielen Dank für die Teilnahme an unserem Experiment. Das Konzert ist nun vorbei und wir bitten Dich, die folgenden Fragen spontan und ohne langes Nachdenken zu beantworten. Es geht um Deine eigenen Einschätzungen und Erlebnisse, darum gibt es kein richtig oder falsch, sondern einzig Deine subjektive Einschätzung.

Code:
Bitte trage hier wieder Dein Codewort ein.

Die ersten beiden Buchstaben des Vornamens Deiner Mutter: ___ ___
Den Geburtstag Deiner Mutter (nur der Tag): ___ ___
Deinen eigenen Geburtstag (nur der Tag): ___ ___

→ **Daraus ergibt sich Dein Codewort: ___ ___ ___ ___ ___ ___**

Wie fühlst Du Dich hier und jetzt?
Bitte gib an, wo Du Dich jeweils zwischen den beiden Eigenschaftspaaren einordnen würdest.
Bitte setze in jeder Zeile ein Kreuz.

	(3) sehr	(2)	(1)	(0) unentschieden	(1)	(2)	(3) sehr	
besorgt	☐	☐	☐	☐	☐	☐	☐	sorgenfrei
gestresst	☐	☐	☐	☐	☐	☐	☐	entspannt
zufrieden	☐	☐	☐	☐	☐	☐	☐	unzufrieden
lustlos	☐	☐	☐	☐	☐	☐	☐	hoch motiviert
ruhig	☐	☐	☐	☐	☐	☐	☐	nervös
unglücklich	☐	☐	☐	☐	☐	☐	☐	glücklich
friedlich	☐	☐	☐	☐	☐	☐	☐	verärgert
begeistert	☐	☐	☐	☐	☐	☐	☐	gelangweilt
müde	☐	☐	☐	☐	☐	☐	☐	hellwach
energiegeladen	☐	☐	☐	☐	☐	☐	☐	energielos

bitte wenden (die Seiten sind doppelseitig bedruckt)

Inwieweit stimmst Du den folgenden Aussagen zu? Bitte bewerte die folgenden Aussagen.
Bitte setze in jeder Zeile ein Kreuz.

	stimme ganz und gar nicht zu	stimme nicht zu	weder noch	stimme zu	stimme voll und ganz zu
Die Mitglieder des Publikums hatten sehr viel gemeinsam.	☐	☐	☐	☐	☐
Ich habe noch ein gutes Bild vom Publikum in meinem Kopf.	☐	☐	☐	☐	☐
Ich habe das Publikum nicht wirklich bemerkt.	☐	☐	☐	☐	☐
Ich war froh, ein Teil des Publikums zu sein.	☐	☐	☐	☐	☐
Ich habe beobachtet, wie sich das Publikum verhalten hat.	☐	☐	☐	☐	☐
Ich hatte vieles gemeinsam mit den durchschnittlichen Mitgliedern des Publikums.	☐	☐	☐	☐	☐
Ich empfand Solidarität mit den anderen Publikumsmitgliedern.	☐	☐	☐	☐	☐
Ich habe kaum auf das Publikum geachtet.	☐	☐	☐	☐	☐
Ich kann mich noch gut daran erinnern, wie das Publikum aussah.	☐	☐	☐	☐	☐
Ich fühlte mich mit den anderen Publikumsmitgliedern verbunden.	☐	☐	☐	☐	☐
Es war angenehm, im Publikum zu sein.	☐	☐	☐	☐	☐
Ich habe nur einen flüchtigen Eindruck vom Publikum bekommen.	☐	☐	☐	☐	☐
Das Publikum zog meine Aufmerksamkeit auf sich.	☐	☐	☐	☐	☐
Die Mitglieder des Publikums waren einander sehr ähnlich.	☐	☐	☐	☐	☐
Ein Teil des Publikums zu sein, gab mir ein gutes Gefühl.	☐	☐	☐	☐	☐
Ich war den durchschnittlichen Publikumsmitgliedern ähnlich.	☐	☐	☐	☐	☐
Ich fühlte mich dem Publikum gegenüber verpflichtet.	☐	☐	☐	☐	☐

Bitte bewerte die folgenden Aussagen zum eben erlebten Konzert.
Bitte setze in jeder Zeile ein Kreuz.

	sehr schlecht	schlecht	neutral	gut	sehr gut
Die Musiker:innen live zu erleben fand ich…	☐	☐	☐	☐	☐
Die Interaktion zwischen Musiker:innen und Publikum fand ich…	☐	☐	☐	☐	☐
Die Interpretation der Musikstücke fand ich…	☐	☐	☐	☐	☐
Das Klima im Raum (Temperatur/Luftfeuchtigkeit) fand ich…	☐	☐	☐	☐	☐
Den Klang der Musik im Raum (Akustik) fand ich…	☐	☐	☐	☐	☐
Die Auswahl und die Zusammenstellung der Musikstücke (musikalische Dramaturgie) fand ich …	☐	☐	☐	☐	☐
Die Bands/die Musiker:innen fand ich…	☐	☐	☐	☐	☐
Die Bühnenshow fand ich…	☐	☐	☐	☐	☐
Die Größe des Konzertraumes fand ich…	☐	☐	☐	☐	☐
Die Möglichkeit zum Gespräch mit anderen und dem Beisammensein vor und nach dem Konzert fand ich…	☐	☐	☐	☐	☐
Das Konzert alles in allem fand ich…	☐	☐	☐	☐	☐
Die Eignung des Konzertortes für ein derartiges Konzert fand ich…	☐	☐	☐	☐	☐

bitte wenden (die Seiten sind doppelseitig bedruckt)

Inwiefern hast Du eben im Konzert die folgenden Erfahrungen machen können? Bitte bewerte die folgenden Aussagen.
Bitte setze in jeder Zeile ein Kreuz.

	stimme gar nicht zu	stimme eher nicht zu	neutral	stimme eher zu	stimme voll und ganz zu
Ich wurde durch Nebengeräusche oder Anderes gestört.	☐	☐	☐	☐	☐
Während des Konzerts verspürte ich den Wunsch, mich zu bewegen oder zu tanzen.	☐	☐	☐	☐	☐
Ich habe mich während des Konzerts wohlgefühlt.	☐	☐	☐	☐	☐
Ich wurde emotional berührt/bewegt.	☐	☐	☐	☐	☐
Ich wurde vom Alltag abgelenkt, konnte abschalten und entspannen.	☐	☐	☐	☐	☐
Ich fühlte mich durch die Video-Aufnahmen gehemmt oder eingeschränkt.	☐	☐	☐	☐	☐
Während des Konzerts verspürte ich den Wunsch mitzusingen.	☐	☐	☐	☐	☐
Ich konnte mit allen Sinnen in die Musik eintauchen.	☐	☐	☐	☐	☐
Ich fühlte mich durch die Messgeräte gehemmt oder eingeschränkt.	☐	☐	☐	☐	☐

Abschließend möchten wir Dich noch um folgende Auskünfte bitten:

Wie vertraut warst Du mit der heute Abend gehörten Musik?

sehr	etwas	eher nicht	überhaupt nicht
☐	☐	☐	☐

Kanntest Du einzelne Songs?

ja, alle	manche	nein, keinen
☐	☐	☐

Wie viele Personen kanntest Du im Publikum? Bitte nenne die ungefähre Anzahl.

_____ Personen

Warst Du an diesem Abend in irgendeiner Form beteiligt? (z. B. als Musiker:in, Fachschaft…)

ja	nein
☐	☐

Hast Du vor oder während des Konzerts Alkohol getrunken?

ja	nein
☐	☐

Falls ja: Wie viel alkoholische Getränke hast Du getrunken? (Volumen Bier/Radler/Wein…)

_____

Hast Du heute Substanzen eingenommen (Beeinflussung der Messung durch z. B. Betablocker, Marihuana)?

ja	nein
☐	☐

Ist Dein Hörvermögen eingeschränkt?

ja	nein
☐	☐

Gibt es noch etwas, das Du uns sagen möchtest?

Vielen herzlichen Dank fürs Mitmachen und Deine Unterstützung des Forschungsprojekts.
Du kannst nun den ausgefüllten Fragebogen abgeben und erhältst dann die Aufwandsentschädigung von 10 € in bar.

C Supplementary Material for Concert Data-set 2

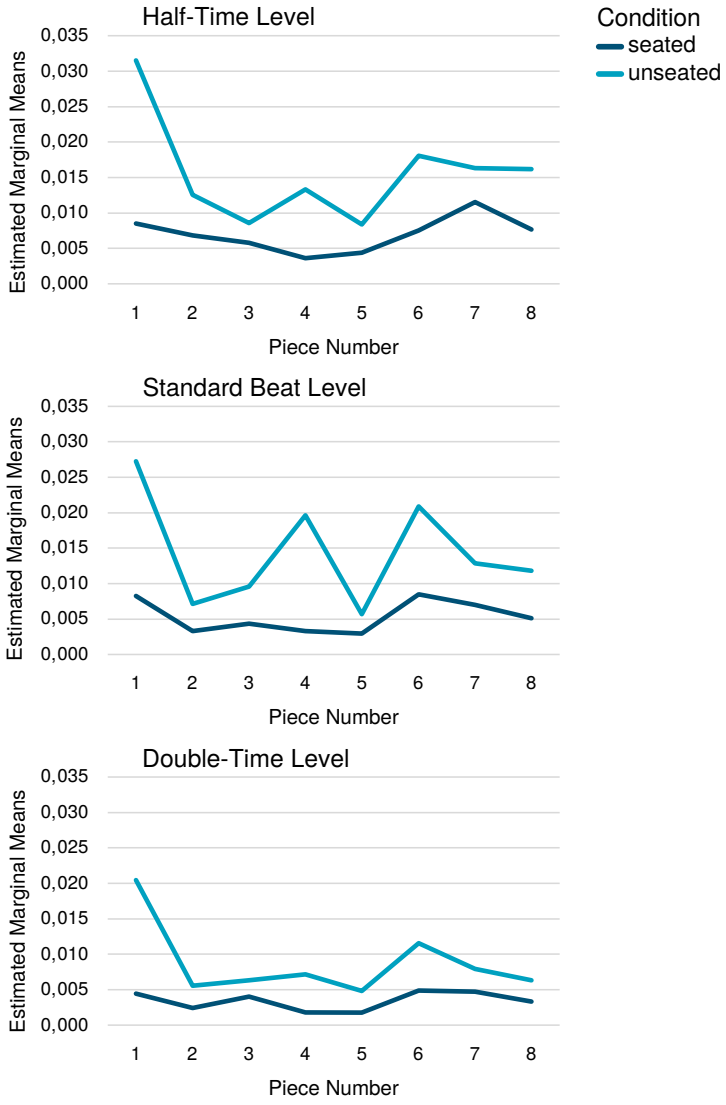


Figure C.1: Estimated marginal means of movement entrainment.

Note. Data are distinguished by the three metrical levels half-time, standard beat, and double-time level and the concert condition (seated and unseated).

Table C.1: M1 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.03	0.07	3287	0.39	.699
Arm (vs. Torso)	0.35	0.03	3287	12.04	<.001
Half Time Level (vs. BPM Level)	–0.34	0.04	3287	–9.65	<.001
Double Time Level (vs. BPM Level)	–0.26	0.04	3287	–7.34	<.001

Table C.2: M2 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.59	0.08	3280	7.78	<.001
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.82	<.001

Table C.3: M3 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	–0.31	0.08	3286	–4.04	<.001
Arm (vs. Torso)	0.35	0.03	3286	12.10	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3286	–9.70	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3286	–7.38	<.001
Tempo	0.08	0.01	3286	5.73	<.001

Table C.4: M4 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.09	0.07	3285	1.22	.221
Arm (vs. Torso)	0.35	0.03	3285	12.19	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3285	–9.76	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3285	–7.43	<.001
Slower than Sweet Spot (vs. Sweet Spot)	–0.30	0.04	3285	–7.80	<.001
Faster than Sweet Spot (vs. Sweet Spot)	0.03	0.03	3285	0.77	.440

Table C.5: M4a – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.08	0.07	3283	1.16	.247
Arm (vs. Torso)	0.35	0.03	3283	12.20	<.001
Half Time Level (vs. BPM Level)	–0.30	0.04	3283	–7.51	<.001
Double Time Level (vs. BPM Level)	–0.28	0.04	3283	–7.39	<.001
Faster Than Sweet Spot (vs. Sweet Spot)	0.069	0.04	3283	1.69	.092
Slower Than Sweet Spot (vs. Sweet Spot)	–0.34	0.05	3283	–7.44	<.001
Half Time Level (vs. BPM Level) × Faster Than Sweet Spot (vs. Sweet Spot)	0.12	0.07	3283	1.56	.119
Double Time Level (vs. BPM Level) × Slower Than Sweet Spot (vs. Sweet Spot)	–0.13	0.07	3283	–1.91	.057

Table C.6: M5 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.10	3280	2.88	.004
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.52	0.11	68	4.61	<.001

Table C.7: M6 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.29	0.10	3280	2.96	.003
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.51	0.12	63	4.34	<.001
Urge to Dance	0.13	0.07	63	1.71	.092
Body Awareness	–0.03	0.06	63	–0.48	.632
Dance Training	–0.02	0.06	63	–0.29	.770
Observational Dance Experience	0.01	0.06	63	0.19	.848
Social Dancing	0.04	0.07	63	0.58	.565

Table C.8: M7 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.09	3280	2.95	.003
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.53	0.11	67	4.91	<.001
Urge to Dance	0.15	0.05	67	2.88	.005

Table C.9: M8 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.29	0.09	3280	3.09	.002
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.50	0.11	66	4.60	<.001
Urge to Dance	0.17	0.06	66	3.11	.003
Positive Activation	–0.07	0.06	66	–1.18	.244

Table C.10: M9 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.09	3280	2.99	.003
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.52	0.11	66	4.82	<.001
Urge to Dance	0.13	0.06	66	2.37	.021
Trait Empathy	0.05	0.06	66	0.94	.349

Table C.11: M10 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.09	3280	2.91	.004
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.53	0.11	66	4.88	<.001
Urge to Dance	0.15	0.05	66	2.77	.007
Liking the Concert	0.02	0.05	66	0.29	.774

Table C.12: M11 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.09	3280	2.95	.003
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.53	0.11	66	4.87	<.001
Urge to Dance	0.15	0.05	66	2.83	.006
Liking Jazz Music	0.04	0.05	66	0.67	.502

Table C.13: M12 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.09	3280	2.95	.003
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.53	0.11	66	4.88	<.001
Urge to Dance	0.16	0.05	66	2.95	.004
Being Familiar With the Music	0.04	0.05	66	0.79	.432

Table C.14: M13 – Fixed effects of the HLM predicting Movement Entrainment.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.27	0.09	3280	2.88	.004
Arm (vs. Torso)	0.35	0.03	3280	12.73	<.001
Half Time Level (vs. BPM Level)	–0.34	0.03	3280	–10.19	<.001
Double Time Level (vs. BPM Level)	–0.26	0.03	3280	–7.76	<.001
Piece 2 (vs. Piece 1)	–0.85	0.05	3280	–15.62	<.001
Piece 3 (vs. Piece 1)	–0.73	0.05	3280	–13.46	<.001
Piece 4 (vs. Piece 1)	–0.47	0.05	3280	–8.66	<.001
Piece 5 (vs. Piece 1)	–0.85	0.05	3280	–15.68	<.001
Piece 6 (vs. Piece 1)	–0.35	0.05	3280	–6.52	<.001
Piece 7 (vs. Piece 1)	–0.65	0.05	3280	–11.90	<.001
Piece 8 (vs. Piece 1)	–0.64	0.05	3280	–11.81	<.001
Standing (vs. Sitting)	0.55	0.11	66	5.17	<.001
Urge to Dance	0.14	0.05	66	2.65	.010
Live Experience	0.10	0.05	66	1.99	.051

Table C.15: Structural regression paths predicting latent constructs of the SECS.

Outcome	Predictor	*Estimate*	*SE*	*z*	*p*	Std.lv	Std.all
Satisfaction	Standing (vs. Sitting)	0.05	0.29	0.16	.88	0.04	0.02
	Familiar Audience Members	–0.00	0.03	–0.11	.91	–0.00	–0.02
	Age	–0.01	0.01	–0.64	.53	–0.01	–0.07
	Active Engagement with Music	0.06	0.03	1.81	.07	0.05	0.24
	Positive Activation	0.27	0.16	1.76	.08	0.25	0.28
	Negative Activation	–0.21	0.17	–1.29	.20	–0.20	–0.19
	Valence	0.24	0.16	1.49	.14	0.22	0.26
Attention	**Standing (vs. Sitting)**	**0.80**	**0.22**	**3.64**	**<.001**	**0.88**	**0.43**
	Familiar Audience Members	–0.04	0.03	–1.42	.16	–0.05	–0.21
	Age	0.01	0.01	0.62	.54	0.01	0.08
	Active Engagement with Music	–0.00	0.02	–0.06	.95	–0.00	–0.01
	Positive Activation	–0.18	0.15	–1.18	.24	–0.20	–0.22
	Negative Activation	0.07	0.12	0.56	.58	0.07	0.07
	Valence	–0.07	0.14	–0.53	.59	–0.08	–0.10
Self-	Standing (vs. Sitting)	0.24	0.18	1.31	.19	0.39	0.19
Definition	Familiar Audience Members	–0.02	0.03	–0.55	.59	–0.03	–0.12
	Age	0.01	0.01	0.83	.41	0.01	0.12
	Active Engagement with Music	0.03	0.02	1.42	.16	0.05	0.21
	Positive Activation	–0.14	0.13	–1.13	.26	–0.23	–0.26
	Negative Activation	0.01	0.10	0.14	.89	0.02	0.02
	Valence	0.22	0.12	1.74	.08	0.35	0.42

- continued on next page -

Table C.15: Structural regression paths predicting latent constructs – *continued from previous page*

Outcome	Predictor	*Estimate*	*SE*	*z*	*p*	Std.lv	Std.all
Solidarity	**Standing (vs. Sitting)**	**0.61**	**0.23**	**2.67**	**.01**	**0.82**	**0.41**
	Familiar Audience Members	**0.07**	**0.02**	**4.51**	**<.001**	**0.09**	**0.39**
	Age	0.01	0.01	0.83	.41	0.01	0.10
	Active Engagement with Music	**0.04**	**0.02**	**2.02**	**.04**	**0.06**	**0.27**
	Positive Activation	**0.29**	**0.14**	**2.04**	**.04**	**0.39**	**0.42**
	Negative Activation	–0.18	0.13	–1.43	.15	–0.24	–0.24
	Valence	0.07	0.12	0.61	.54	0.10	0.11
Depth of	**Standing (vs. Sitting)**	**0.80**	**0.29**	**2.78**	**.01**	**0.88**	**0.44**
Processing	Familiar Audience Members	–0.02	0.04	–0.64	.52	–0.03	–0.12
	Age	0.00	0.01	0.33	.74	0.00	0.04
	Active Engagement with Music	0.03	0.03	1.02	.31	0.03	0.14
	Positive Activation	–0.01	0.16	–0.08	.94	–0.01	–0.02
	Negative Activation	0.18	0.14	1.35	.18	0.20	0.20
	Valence	0.04	0.15	0.27	.79	0.05	0.06

Note. Significant effects are in bold.

Further Results From the Questionnaires

Liking the concert: *All in all, I found the concert...* [orig.: *Das Konzert alles in allem fand ich...*] (1–5 Likert scale, 1 = *very bad*, 5 = *very good*):

Concert 1: *M* = 4.39, *SD* = 0.63

Concert 2: *M* = 4.24, *SD* = 0.83

Liking jazz music: *Please indicate your basic preference for each of the following genres using the scale provided: Jazz* [orig.: *Bitte geben Sie Ihre Präferenzen für jedes der folgenden Musikgenres anhand der gegebenen Skala an: Jazz*] (1–7 Likert scale, 1 = *dislike strongly*, 7 = *like strongly*):

Concert 1: *M* = 5.04, *SD* = 1.75

Concert 2: *M* = 5.10, *SD* = 1.63

Empathy (Paulus, 2009) (index of four questions on 1–5 scales):

Concert 1: *M* = 15.25, *SD* = 2.66

Concert 2: *M* = 15.63, *SD* = 3.17

Dance Sophistication Index (Rose et al., 2022) (1–7 Likert scales, 1 = *completely disagree*, 7 = *completely agree*; *Items were reverse-coded):

Participatory Dance Experience

P1: Body Awareness: *I am not very coordinated.* [orig.: *Ich bin nicht sehr geschickt, wenn ich mich bewege.*]*

Concert 1: *M* = 4.89, *SD* = 1.77

Concert 2: *M* = 3.90, *SD* = 1.67

P2: Social Dancing: *I like dancing in front of people.* [orig.: *Ich mag es vor anderen Leuten zu tanzen.*]

Concert 1: *M* = 3.25, *SD* = 1.82

Concert 2: *M* = 3.67, *SD* = 2.16

P3: Urge to Dance: *When I hear a great track, it just makes me want to dance.* [orig.: *Wenn ich ein tolles Musikstück höre, muss ich einfach anfangen zu tanzen.*]

Concert 1: *M* = 4.43, *SD* = 2.01

Concert 2: *M* = 4.27, *SD* = 2.05

P4: Dance Training: *I have had formal training in any dance style for: 0 years; 0.5 years; 1 year; 2 years; 3 years; 4 – 6 years; 7 or more years* [orig.: *Ich hatte formales Training für einen bestimmten Tanzstil für … Jahre*]

Concert 1: *M* = 2.14, *SD* = 1.82

Concert 2: *M* = 2.39, *SD* = 1.94

Observational Dance Experience: *If I had to choose, I'd rather watch a theater play than a dance performance.* [orig: *Wenn ich die Wahl hätte, würde ich mir lieber ein Theaterstück als eine Tanzaufführung angucken.*]*

Concert 1: *M* = 4.18, *SD* = 1.59

Concert 2: *M* = 3.98, *SD* = 1.67

PANAVA (Schallberger, 2005) (mean indices of 1–7 scales):

Positive Activation:

Concert 1: *M* = 4.92, *SD* = 0.90

Concert 2: *M* = 4.50, *SD* = 1.12

Negative Activation:

Concert 1: *M* = 2.53, *SD* = 0.90

Concert 2: *M* = 2.79, *SD* = 1.02

Valence:

Concert 1: *M* = 5.91, *SD* = 0.75

Concert 2: *M* = 5.27, *SD* = 1.36

Being familiar with the music: *How familiar were you with the music you heard tonight?* [orig.: *Wie vertraut waren Sie mit der heute Abend gehörten Musik?*] (1–4 Likert scale, 1 = *very much*, 4 = *not at all*):

Concert 1: *M* = 2.39, *SD* = 0.99

Concert 2: *M* = 2.44, *SD* = 1.00

Live experience: *I found experiencing the musicians live...* [orig.: *Die Musiker:innen live zu erleben fand ich...*] (1–5 Likert scale, 1 = *very bad*, 5 = *very good*):

Concert 1: *M* = 4.57, *SD* = 0.51

Concert 2: *M* = 4.46, *SD* = 0.67

D Questionnaires for Concert Dataset 2

Please note that the questionnaires were implemented through the online survey platform Unipark[1].

[1] https://www.unipark.com

D.1 Pre-Concert Questionnaire

Wie fühlen Sie sich hier und jetzt?

Bitte geben Sie an, wo Sie sich jeweils zwischen den beiden Eigenschaftspaaren einordnen würden.

besorgt	○	○	○	○	○	○	○	sorgenfrei
gestresst	○	○	○	○	○	○	○	entspannt
zufrieden	○	○	○	○	○	○	○	unzufrieden
energiegeladen	○	○	○	○	○	○	○	energielos
müde	○	○	○	○	○	○	○	hellwach
friedlich	○	○	○	○	○	○	○	verärgert
unglücklich	○	○	○	○	○	○	○	glücklich
lustlos	○	○	○	○	○	○	○	hoch motiviert
ruhig	○	○	○	○	○	○	○	nervös
begeistert	○	○	○	○	○	○	○	gelangweilt

Welchen höchsten beruflichen Ausbildungsabschluss haben Sie?

Kreuzen Sie bitte eine der folgenden Optionen an:

- ◯ Noch in beruflicher Ausbildung (Auszubildende:r, Praktikant:in, Student:in)
- ◯ Schüler:in und besuche eine berufsorientierte Aufbau-, Fachschule o. Ä.
- ◯ Ich habe keinen beruflichen Abschluss und bin nicht in beruflicher Ausbildung
- ◯ Beruflich-betriebliche Berufsausbildung (Lehre) abgeschlossen
- ◯ Beruflich-schulische Ausbildung (z. B. Berufsfachschule, Handelsschule abgeschlossen)
- ◯ Ausbildung an einer Meister-, Technikerschule, Berufs- oder Fachakademie abgeschlossen
- ◯ Bachelor an (Fach-)Hochschule abgeschlossen
- ◯ Fachhochschulabschluss (z. B. Diplom, Master)
- ◯ Universitätsabschluss (z. B. Diplom, Magister, Staatsexamen, Master)
- ◯ Promotion

Falls Sie aktuell studieren oder studiert haben: Welche Fächer studier(t)en Sie?

Wie fühlen Sie sich hier und jetzt?

Bitte geben Sie an, wo Sie sich jeweils zwischen den beiden Eigenschaftspaaren einordnen würden.

besorgt	◯	◯	◯	◯	◯	◯	◯	sorgenfrei
gestresst	◯	◯	◯	◯	◯	◯	◯	entspannt
zufrieden	◯	◯	◯	◯	◯	◯	◯	unzufrieden
energiegeladen	◯	◯	◯	◯	◯	◯	◯	energielos
müde	◯	◯	◯	◯	◯	◯	◯	hellwach
friedlich	◯	◯	◯	◯	◯	◯	◯	verärgert
unglücklich	◯	◯	◯	◯	◯	◯	◯	glücklich
lustlos	◯	◯	◯	◯	◯	◯	◯	hoch motiviert
ruhig	◯	◯	◯	◯	◯	◯	◯	nervös
begeistert	◯	◯	◯	◯	◯	◯	◯	gelangweilt

Bitte geben Sie an, wie sehr Sie den folgenden Aussagen zustimmen.

	Stimme ganz und gar nicht zu	Stimme nicht zu	Stimme eher nicht zu	Weder noch	Stimme eher zu	Stimme zu	Stimme voll und ganz zu
Ich beschäftige mich in meiner Freizeit viel mit musikbezogenen Aktivitäten	○	○	○	○	○	○	○
Ich lese oder suche oft im Internet nach Dingen, die mit Musik zu tun haben.	○	○	○	○	○	○	○
Musik ist für mich eine Art von Sucht - ohne sie könnte ich nicht leben.	○	○	○	○	○	○	○
Ich suche oft Musik aus, bei der ich eine Gänsehaut bekomme.	○	○	○	○	○	○	○
Ich suche häufig eine bestimmte Musik aus, um mich zu motivieren oder zu begeistern.	○	○	○	○	○	○	○
Musik kann bei mir Erinnerungen an Personen und Orte hervorrufen.	○	○	○	○	○	○	○
Ich bin noch nie für meine musikalischen Fähigkeiten gelobt worden.	○	○	○	○	○	○	○
Ich kann beurteilen, ob jemand gut singt oder nicht.	○	○	○	○	○	○	○
Ich kann beurteilen, ob jemand nicht im Rhythmus mit der Musik singt oder spielt.	○	○	○	○	○	○	○
Ich kann beurteilen, ob jemand falsch oder richtig singt oder spielt.	○	○	○	○	○	○	○
Ich kann auswendig singen oder Musik spielen.	○	○	○	○	○	○	○
Ich bin in der Lage, die richtigen Töne zu treffen, wenn ich zu einer Aufnahme mitsinge.	○	○	○	○	○	○	○
Wenn jemand anderes ein Lied singt, das ich kenne, kann ich eine zweite Stimme dazu singen.	○	○	○	○	○	○	○

Bitte machen Sie folgende Angaben:

Ich habe regelmäßig und täglich ein Instrument (einschließlich Gesang) für __ Jahre geübt.

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4–5
- ◯ 6–9
- ◯ 10 oder mehr

An dem Höhepunkt meines Interesses habe ich mein Hauptinstrument __ Stunden pro Tag geübt.

- ◯ 0
- ◯ 0,5
- ◯ 1
- ◯ 1,5
- ◯ 2
- ◯ 3–4
- ◯ 5 oder mehr

Ich kann __ verschiedene Instrumente spielen.

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 6 oder mehr
- ◯ 5

D Questionnaires for Concert Dataset 2

Sie werden jetzt eine Reihe von Aussagen lesen, die jeweils bestimmte (verallgemeinerte) menschliche Eigenschaften oder Reaktionen beschreiben, die alle etwas mit Gefühlen zu tun haben. Bitte kreuzen Sie an, inwieweit diese Aussage auf Sie zutreffen. Vielleicht fällt Ihnen auch zu der einen oder anderen allgemeinen Beschreibung ein konkretes Erlebnis ein.
Es gibt dabei keine richtigen oder falschen Antworten.

	Nie	Selten	Manchmal	Oft	Immer
Ich empfinde warmherzige Gefühle für Leute, denen es weniger gut geht als mir.	○	○	○	○	○
Mich berühren Dinge sehr, auch wenn ich sie nur beobachte.	○	○	○	○	○
Wenn mir das Verhalten einer anderen Person komisch vorkommt, versuche ich mich für eine Weile in ihre Lage zu versetzen.	○	○	○	○	○
Bevor ich eine Person kritisiere, versuche ich mir vorzustellen, wie ich mich an ihrer Stelle fühlen würde.	○	○	○	○	○

Wie sehr stimmen Sie den folgenden Aussagen zu?

	Stimme ganz und gar nicht zu	Stimme nicht zu	Stimme eher nicht zu	Weder noch	Stimme eher zu	Stimme zu	Stimme voll und ganz zu
Ich bin nicht sehr geschickt, wenn ich mich bewege.	◯	◯	◯	◯	◯	◯	◯
Ich mag es vor anderen Leuten zu tanzen.	◯	◯	◯	◯	◯	◯	◯
Wenn ich ein tolles Musikstück höre, muss ich einfach anfangen zu tanzen.	◯	◯	◯	◯	◯	◯	◯
Wenn ich die Wahl hätte, würde ich mir lieber ein Theaterstück als eine Tanzaufführung angucken.	◯	◯	◯	◯	◯	◯	◯

Ich hatte formales Training für einen bestimmten Tanzstil für __ Jahre.

- ◯ 0
- ◯ 0,5
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4–6
- ◯ 7 oder mehr

Bitte geben Sie Ihre Präferenzen für jedes der folgenden Musikgenres anhand der gegebenen Skala an.

	Gefällt mir überhaupt nicht	Gefällt mir größtenteils nicht	Gefällt mir eher nicht	Weder noch	Gefällt mir eher	Gefällt mir größtenteils	Gefällt mir voll und ganz
Alternative	◯	◯	◯	◯	◯	◯	◯
Bluegrass	◯	◯	◯	◯	◯	◯	◯
Blues	◯	◯	◯	◯	◯	◯	◯
Klassische Musik	◯	◯	◯	◯	◯	◯	◯
Country	◯	◯	◯	◯	◯	◯	◯
Electronica/Dance	◯	◯	◯	◯	◯	◯	◯
Folk	◯	◯	◯	◯	◯	◯	◯
Funk	◯	◯	◯	◯	◯	◯	◯
Gospel	◯	◯	◯	◯	◯	◯	◯
Heavy Metal	◯	◯	◯	◯	◯	◯	◯
Weltmusik	◯	◯	◯	◯	◯	◯	◯
Jazz	◯	◯	◯	◯	◯	◯	◯
New Age	◯	◯	◯	◯	◯	◯	◯
Oldies	◯	◯	◯	◯	◯	◯	◯
Oper	◯	◯	◯	◯	◯	◯	◯
Pop	◯	◯	◯	◯	◯	◯	◯
Punk	◯	◯	◯	◯	◯	◯	◯
Rap/Hip-Hop	◯	◯	◯	◯	◯	◯	◯
Reggae	◯	◯	◯	◯	◯	◯	◯
Religiöse Musik	◯	◯	◯	◯	◯	◯	◯
Rock	◯	◯	◯	◯	◯	◯	◯
Soul/R&B	◯	◯	◯	◯	◯	◯	◯
Filmmusik/Soundtracks	◯	◯	◯	◯	◯	◯	◯

Vielen Dank, Sie haben es fast geschafft. Bitte beantworten Sie nun noch die folgenden Fragen zu Ihrem heutigen Konzertbesuch.

Besuchen Sie das Konzert heute in Begleitung?

◯ Ja

◯ Nein

Welche Anzahl an Konzerten (Pop, Rock, Jazz, Klassik, Oper, etc.) haben Sie als Zuhörer:in innerhalb der letzten 12 Monate besucht?

Bitte die Zahl in das Textfeld eintragen.

Wie viele davon waren Jazzkonzerte?

Bitte die Zahl in das Textfeld eintragen.

Bevor Sie gleich weiter zum Verkabeln können, bitten wir Sie, ein individuelles Codewort zu generieren.

Anhand des Codeworts können wir die Daten der physiologischen Messungen Ihren Fragebogendaten zuordnen. Außerdem können Sie damit eine frühzeitige Löschung Ihrer Daten beantragen.

Das Codewort setzt sich zusammen aus:

- Den ersten beiden Buchstaben des Vornamens Ihrer Mutter
- Dem Geburtstag Ihrer Mutter (nur der Tag)
- Dem eigenen Geburtstag (nur der Tag)

Beispiel (fiktiv):

- Vorname der Mutter: Eva
- Geburtstag der Mutter: 10.07.1960
- Ihr Geburtstag: 29.05.1995

Daraus ergibt sich das Codewort: EV1029

Bitte tragen Sie hier Ihr Codewort ein:

Bitte notieren Sie das Codewort auch direkt auf dem Klebeetikett. So können wir Ihren Fragebogen gleich schneller den Sensoren zuordnen.

Gibt es noch etwas, das Sie uns mitteilen möchten?

Sie haben es geschafft – vielen Dank!

Sie können jetzt weiter zum Verkabeln.

Und viel Spaß im Konzert!

D.2 Post-Concert Questionnaire

D.2.1 Sitting Condition

Wie fühlen Sie sich hier und jetzt?

Bitte geben Sie an, wo Sie sich jeweils zwischen den beiden Eigenschaftspaaren einordnen würden.

besorgt	○	○	○	○	○	○	○	sorgenfrei
gestresst	○	○	○	○	○	○	○	entspannt
zufrieden	○	○	○	○	○	○	○	unzufrieden
energiegeladen	○	○	○	○	○	○	○	energielos
müde	○	○	○	○	○	○	○	hellwach
friedlich	○	○	○	○	○	○	○	verärgert
unglücklich	○	○	○	○	○	○	○	glücklich
lustlos	○	○	○	○	○	○	○	hoch motiviert
ruhig	○	○	○	○	○	○	○	nervös
begeistert	○	○	○	○	○	○	○	gelangweilt

Inwieweit stimmen Sie den folgenden Aussagen zu? Bitte bewerten Sie die folgenden Aussagen.

	stimme ganz und gar nicht zu	stimme nicht zu	weder noch	stimme zu	stimme voll und ganz zu
Die Mitglieder des Publikums hatten sehr viel gemeinsam.	○	○	○	○	○
Ich habe noch ein gutes Bild vom Publikum in meinem Kopf.	○	○	○	○	○
Ich habe das Publikum nicht wirklich bemerkt.	○	○	○	○	○
Ich war froh, ein Teil des Publikums zu sein.	○	○	○	○	○
Ich habe beobachtet, wie sich das Publikum verhalten hat.	○	○	○	○	○
Ich hatte vieles gemeinsam mit den durchschnittlichen Mitgliedern des Publikums.	○	○	○	○	○
Ich empfand Solidarität mit den anderen Publikumsmitgliedern.	○	○	○	○	○
Ich habe kaum auf das Publikum geachtet.	○	○	○	○	○
Ich kann mich noch gut daran erinnern, wie das Publikum aussah.	—	—	—	—	—
Ich fühlte mich mit den anderen Publikumsmitgliedern verbunden.	○	○	○	○	○
Es war angenehm, im Publikum zu sein.	○	○	○	○	○
Ich habe nur einen flüchtigen Eindruck vom Publikum bekommen.	○	○	○	○	○
Das Publikum zog meine Aufmerksamkeit auf sich.	○	○	○	○	○
Die Mitglieder des Publikums waren einander sehr ähnlich.	○	○	○	○	○
Ein Teil des Publikums zu sein, gab mir ein gutes Gefühl.	○	○	○	○	○
Ich war den durchschnittlichen Publikumsmitgliedern ähnlich.	○	○	○	○	○
Ich fühlte mich dem Publikum gegenüber verpflichtet.	○	○	○	○	○

Bitte bewerten Sie die folgenden Aussagen zum eben erlebten Konzert.

	sehr schlecht	schlecht	neutral	gut	sehr gut
Die Musiker:innen live zu erleben fand ich...	○	○	○	○	○
Die Interaktion zwischen Musiker:innen und Publikum fand ich...	○	○	○	○	○
Die Interpretation der Musikstücke fand ich...	○	○	○	○	○
Das Klima im Raum (Temperatur/Luft-feuchtigkeit) fand ich...	—	—	—	—	—
Den Klang der Musik im Raum (Akustik) fand ich...	○	○	○	○	○
Die Auswahl und die Zusammenstellung der Musikstücke (musikalische Dramaturgie) fand ich ...	○	○	○	○	○
Die Band/die Musiker:innen fand ich...	○	○	○	○	○
Die Bühnenshow/Performance fand ich...	○	○	○	○	○
Die Größe des Konzertraumes fand ich...	○	○	○	○	○
Die Möglichkeit zum Gespräch mit anderen und dem Beisammensein vor und nach dem Konzert fand ich...	○	○	○	○	○
Das Konzert alles in allem fand ich...	○	○	○	○	○
Die Eignung des Konzertortes für ein derartiges Konzert fand ich...	○	○	○	○	○

D Questionnaires for Concert Dataset 2

Inwiefern haben Sie eben im Konzert die folgenden Erfahrungen machen können? Bitte bewerten Sie die folgenden Aussagen.

	stimme gar nicht zu	stimme eher nicht zu	neutral	stimme eher zu	stimme voll und ganz zu
Ich wurde durch Nebengeräusche oder anderes gestört.	◯	◯	◯	◯	◯
Während des Konzerts verspürte ich den Wunsch, mich zu bewegen oder zu tanzen.	◯	◯	◯	◯	◯
Ich habe mich während des Konzerts wohlgefühlt.	◯	◯	◯	◯	◯
Ich wurde emotional berührt/bewegt.	◯	◯	◯	◯	◯
Ich wurde vom Alltag abgelenkt, konnte abschalten und entspannen.	◯	◯	◯	◯	◯
Ich fühlte mich durch die Video-Aufnahmen gehemmt oder eingeschränkt.	◯	◯	◯	◯	◯
Ich konnte mit allen Sinnen in die Musik eintauchen.	◯	◯	◯	◯	◯
Ich fühlte mich durch die Messgeräte gehemmt oder eingeschränkt.	◯	◯	◯	◯	◯
Ich habe mich zur Musik bewegt.	◯	◯	◯	◯	◯

Fast geschafft! Abschließend möchten wir Sie noch um folgende Auskünfte bitten:

Wie vertraut waren Sie mit der heute Abend gehörten Musik?

- ◯ sehr
- ◯ etwas
- ◯ eher nicht
- ◯ überhaupt nicht

Kannten Sie einzelne Songs/Titel?

- ◯ ja, alle
- ◯ manche
- ◯ nein, keinen

Wie viele Personen kannten Sie im Publikum? Bitte nennen Sie die ungefähre Anzahl.

Bitte die Anzahl der Personen ins Textfeld eintragen.

Wie viele der Musiker:innen kannten Sie?

Bitte die Anzahl der Musiker:innen, die Sie kannten, in das Textfeld eintragen.

War Ihre Sicht auf die Band eingeschränkt?

Zum Beispiel durch eine große vor Ihnen sitzende Person.

- ◯ ja
- ◯ nein

Haben Sie eine körperliche Beeinträchtigung, die das Sitzen beeinflusst?

- ◯ Ja
- ◯ Nein

Ist Ihr Hörvermögen eingeschränkt?

- ◯ ja
- ◯ nein

Haben Sie vor oder während des Konzerts Alkohol getrunken?

- ◯ ja
- ◯ nein

Filter

Wie viel Alkohol haben Sie getrunken? (Volumen Bier/Radler/Wein...)

Zum Schluss bitten wir Sie erneut, Ihr individuelles Codewort anzugeben.

Anhand des Codeworts können wir die Daten der physiologischen Messungen Ihren Fragebogendaten zuordnen.

Das Codewort setzt sich zusammen aus:

- Den ersten beiden Buchstaben des Vornamens Ihrer Mutter
- Dem Geburtstag Ihrer Mutter (nur der Tag)
- Dem eigenen Geburtstag (nur der Tag)

Beispiel (fiktiv):

- Vorname der Mutter: Eva
- Geburtstag der Mutter: 10.07.1960
- Ihr Geburtstag: 29.05.1995

Daraus ergibt sich das Codewort: EV1029

Bitte tragen Sie hier Ihr Codewort ein:

Gibt es noch etwas, das Sie uns sagen möchten?

Dann tragen Sie es gern in dieses Textfeld ein.

Sie haben es geschafft – vielen Dank! Mit Ihrer Teilnahme haben Sie uns sehr geholfen. Die Befragung ist nun vorbei.

Da heute Abend Geld für die Stiftung Kinderglück gesammelt wird, haben wir noch drei kurze Fragen an Sie, die Sie freiwillig beantworten können.

Die Stiftung Kinderglück ist in Dortmund ansässig und setzt sich vermehrt für Kinder und Jugendliche im Raum Dortmund ein. Kannten Sie die Stiftung Kinderglück bereits?

- ◯ ja
- ◯ nein
- ◯ weiß nicht
- ◯ keine Angabe

Wie würden Sie die Stiftung bewerten?

Bitte vergeben Sie maximal 5 Sternchen.

Falls Sie heute für die Stiftung spenden möchten oder bereits gespendet haben: Wie viel spenden Sie bzw. haben Sie gespendet?

Bitte stellen Sie den Betrag am Schieberegler ein.

- ◯ Ich möchte nicht spenden.

Vielen Dank für Ihre Teilnahme!

D.2.2 Standing Condition

Wie fühlen Sie sich hier und jetzt?

Bitte geben Sie an, wo Sie sich jeweils zwischen den beiden Eigenschaftspaaren einordnen würden.

besorgt	○	○	○	○	○	○	○	sorgenfrei
gestresst	○	○	○	○	○	○	○	entspannt
zufrieden	○	○	○	○	○	○	○	unzufrieden
energiegeladen	○	○	○	○	○	○	○	energielos
müde	○	○	○	○	○	○	○	hellwach
friedlich	○	○	○	○	○	○	○	verärgert
unglücklich	○	○	○	○	○	○	○	glücklich
lustlos	○	○	○	○	○	○	○	hoch motiviert
ruhig	○	○	○	○	○	○	○	nervös
begeistert	○	○	○	○	○	○	○	gelangweilt

Inwieweit stimmen Sie den folgenden Aussagen zu? Bitte bewerten Sie die folgenden Aussagen.

	stimme ganz und gar nicht zu	stimme nicht zu	weder noch	stimme zu	stimme voll und ganz zu
Die Mitglieder des Publikums hatten sehr viel gemeinsam.	○	○	○	○	○
Ich habe noch ein gutes Bild vom Publikum in meinem Kopf.	○	○	○	○	○
Ich habe das Publikum nicht wirklich bemerkt.	○	○	○	○	○
Ich war froh, ein Teil des Publikums zu sein.	○	○	○	○	○
Ich habe beobachtet, wie sich das Publikum verhalten hat.	○	○	○	○	○
Ich hatte vieles gemeinsam mit den durchschnittlichen Mitgliedern des Publikums.	○	○	○	○	○
Ich empfand Solidarität mit den anderen Publikumsmitgliedern.	○	○	○	○	○
Ich habe kaum auf das Publikum geachtet.	○	○	○	○	○
Ich kann mich noch gut daran erinnern, wie das Publikum aussah.	—	—	—	—	—
Ich fühlte mich mit den anderen Publikumsmitgliedern verbunden.	○	○	○	○	○
Es war angenehm, im Publikum zu sein.	○	○	○	○	○
Ich habe nur einen flüchtigen Eindruck vom Publikum bekommen.	○	○	○	○	○
Das Publikum zog meine Aufmerksamkeit auf sich.	○	○	○	○	○
Die Mitglieder des Publikums waren einander sehr ähnlich.	○	○	○	○	○
Ein Teil des Publikums zu sein, gab mir ein gutes Gefühl.	○	○	○	○	○
Ich war den durchschnittlichen Publikumsmitgliedern ähnlich.	○	○	○	○	○
Ich fühlte mich dem Publikum gegenüber verpflichtet.	○	○	○	○	○

Bitte bewerten Sie die folgenden Aussagen zum eben erlebten Konzert.

	sehr schlecht	schlecht	neutral	gut	sehr gut
Die Musiker:innen live zu erleben fand ich...	○	○	○	○	○
Die Interaktion zwischen Musiker:innen und Publikum fand ich...	○	○	○	○	○
Die Interpretation der Musikstücke fand ich...	○	○	○	○	○
Das Klima im Raum (Temperatur/Luft-feuchtigkeit) fand ich...	—	—	—	—	—
Den Klang der Musik im Raum (Akustik) fand ich...	○	○	○	○	○
Die Auswahl und die Zusammenstellung der Musikstücke (musikalische Dramaturgie) fand ich ...	○	○	○	○	○
Die Band/die Musiker:innen fand ich...	○	○	○	○	○
Die Bühnenshow/Performance fand ich...	○	○	○	○	○
Die Größe des Konzertraumes fand ich...	○	○	○	○	○
Die Möglichkeit zum Gespräch mit anderen und dem Beisammensein vor und nach dem Konzert fand ich...	○	○	○	○	○
Das Konzert alles in allem fand ich...	○	○	○	○	○
Die Eignung des Konzertortes für ein derartiges Konzert fand ich...	○	○	○	○	○

Inwiefern haben Sie eben im Konzert die folgenden Erfahrungen machen können? Bitte bewerten Sie die folgenden Aussagen.

	stimme gar nicht zu	stimme eher nicht zu	neutral	stimme eher zu	stimme voll und ganz zu
Ich wurde durch Nebengeräusche oder anderes gestört.	○	○	○	○	○
Während des Konzerts verspürte ich den Wunsch, mich zu bewegen oder zu tanzen.	○	○	○	○	○
Ich habe mich während des Konzerts wohlgefühlt.	○	○	○	○	○
Ich wurde emotional berührt/bewegt.	○	○	○	○	○
Ich wurde vom Alltag abgelenkt, konnte abschalten und entspannen.	○	○	○	○	○
Ich fühlte mich durch die Video-Aufnahmen gehemmt oder eingeschränkt.	○	○	○	○	○
Ich konnte mit allen Sinnen in die Musik eintauchen.	○	○	○	○	○
Ich fühlte mich durch die Messgeräte gehemmt oder eingeschränkt.	○	○	○	○	○
Ich habe mich zur Musik bewegt.	○	○	○	○	○

Fast geschafft! Abschließend möchten wir Sie noch um folgende Auskünfte bitten:

Wie vertraut waren Sie mit der heute Abend gehörten Musik?

- ○ sehr
- ○ etwas
- ○ eher nicht
- ○ überhaupt nicht

Kannten Sie einzelne Songs/Titel?

- ○ ja, alle
- ○ manche
- ○ nein, keinen

Wie viele Personen kannten Sie im Publikum? Bitte nennen Sie die ungefähre Anzahl.

Bitte die Anzahl der Personen ins Textfeld eintragen.

Wie viele der Musiker:innen kannten Sie?

Bitte die Anzahl der Musiker:innen, die Sie kannten, in das Textfeld eintragen.

War Ihre Sicht auf die Band eingeschränkt?

Zum Beispiel durch eine große vor Ihnen stehende Person.

- ◯ ja
- ◯ nein

Haben Sie eine körperliche Beeinträchtigung, die das Stehen beeinflusst?

- ◯ Ja
- ◯ Nein

Ist Ihr Hörvermögen eingeschränkt?

- ◯ ja
- ◯ nein

Haben Sie vor oder während des Konzerts Alkohol getrunken?

- ◯ ja
- ◯ nein

Filter

Wie viel Alkohol haben Sie getrunken? (Volumen Bier/Radler/Wein...)

Zum Schluss bitten wir Sie erneut, Ihr individuelles Codewort anzugeben.

Anhand des Codeworts können wir die Daten der physiologischen Messungen Ihren Fragebogendaten zuordnen.

Das Codewort setzt sich zusammen aus:

- Den ersten beiden Buchstaben des Vornamens Ihrer Mutter
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- Dem eigenen Geburtstag (nur der Tag)

Beispiel (fiktiv):

- Vorname der Mutter: Eva
- Geburtstag der Mutter: 10.07.1960
- Ihr Geburtstag: 29.05.1995

Daraus ergibt sich das Codewort: EV1029

Bitte tragen Sie hier Ihr Codewort ein:

Gibt es noch etwas, das Sie uns sagen möchten?

Dann tragen Sie es gern in dieses Textfeld ein.

Sie haben es geschafft – vielen Dank! Mit Ihrer Teilnahme haben Sie uns sehr geholfen. Die Befragung ist nun vorbei.

Da heute Abend Geld für die Stiftung Kinderglück gesammelt wird, haben wir noch drei kurze Fragen an Sie, die Sie freiwillig beantworten können.

Die Stiftung Kinderglück ist in Dortmund ansässig und setzt sich vermehrt für Kinder und Jugendliche im Raum Dortmund ein. Kannten Sie die Stiftung Kinderglück bereits?

- ◯ ja
- ◯ nein
- ◯ weiß nicht
- ◯ keine Angabe

Wie würden Sie die Stiftung bewerten?

Bitte vergeben Sie maximal 5 Sternchen.



Falls Sie heute für die Stiftung spenden möchten oder bereits gespendet haben: Wie viel spenden Sie bzw. haben Sie gespendet?

Bitte stellen Sie den Betrag am Schieberegler ein.

- ◯ Ich möchte nicht spenden.

Vielen Dank für Ihre Teilnahme!

E Supplementary Material for Concert Dataset 3

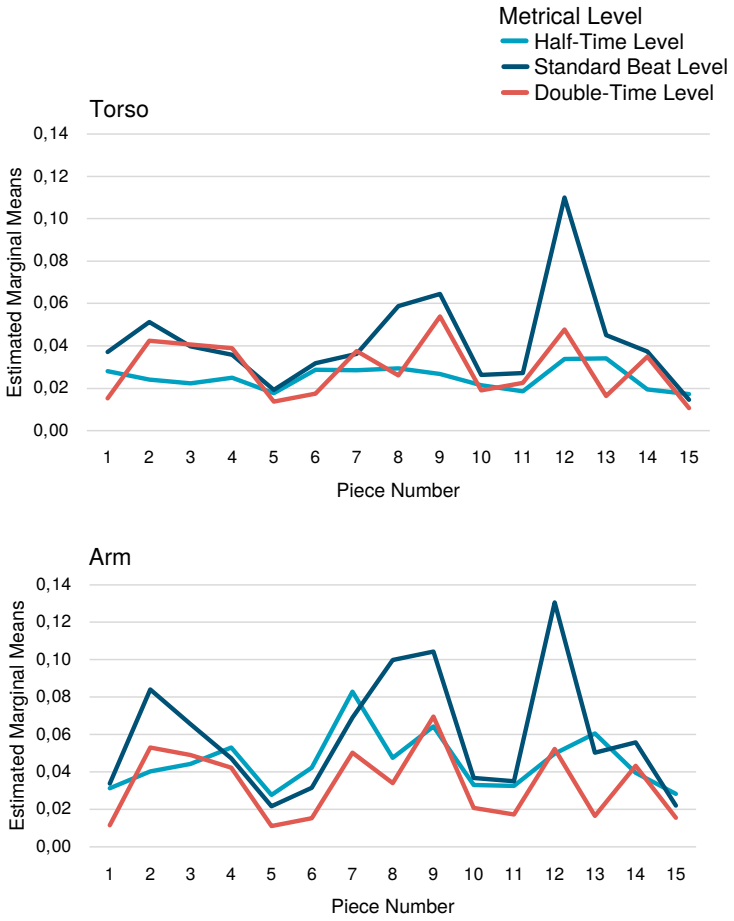


Figure E.1: Estimated marginal means of movement entrainment.

Note. Data are distinguished by location of measurement (torso and arm) and by the three metrical levels half-time, standard beat, and double-time level.

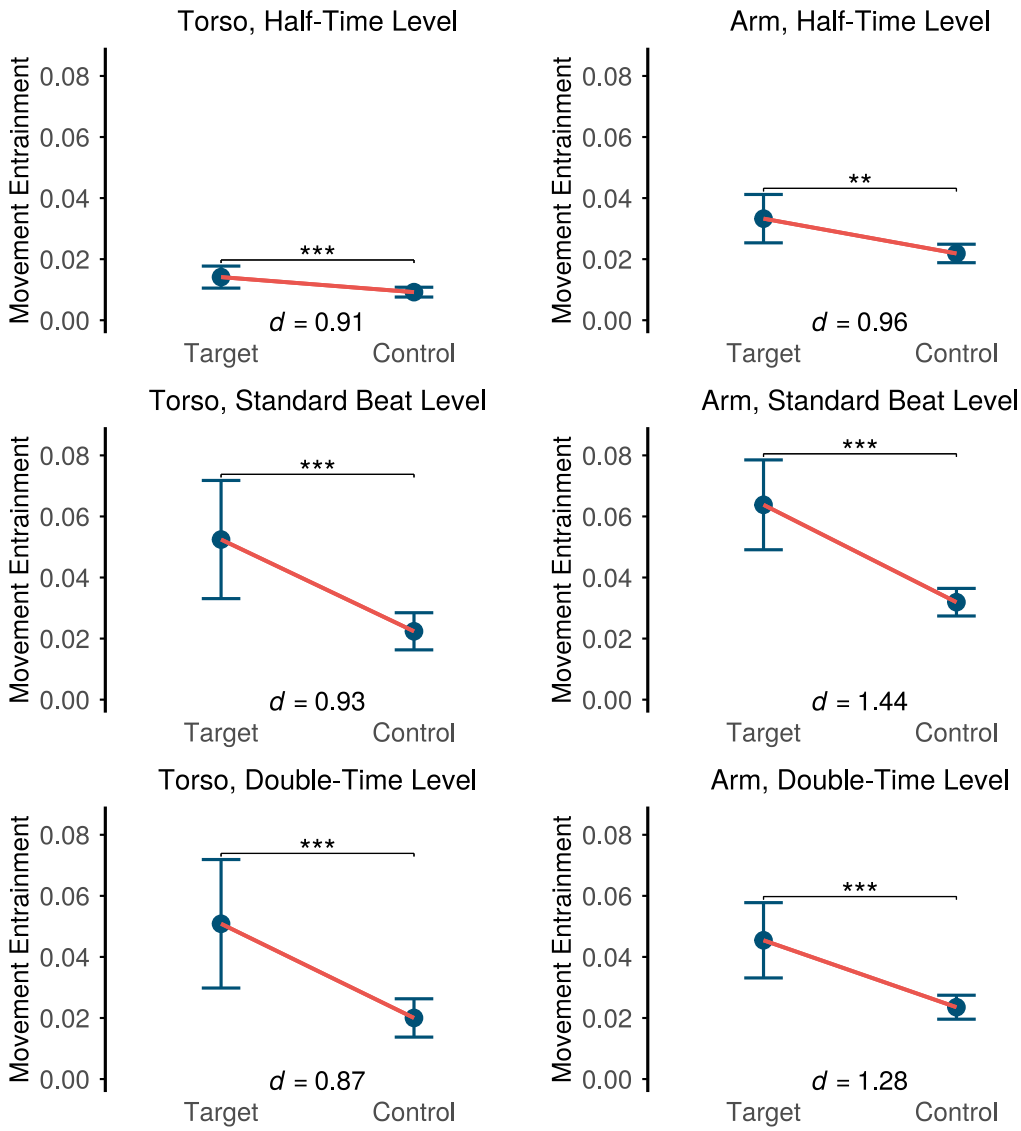


Figure E.2: Mean values of Movement Entrainment calculated for the target BPM values of all pieces compared to values for Movement Entrainment calculated for control BPM values.

Note. Results for the two locations of measurement (arm and torso) and the three metrical levels (half-time, standard beat level, and double-time) are shown in the six plots. For the control values, movement entrainment was analysed for + and – 10, 20 and 30 BPM around the target value, then averaged. Error bars mark 95% confidence intervals. Effect sizes represent differences between movement entrainment calculated for target and control BPM values.

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

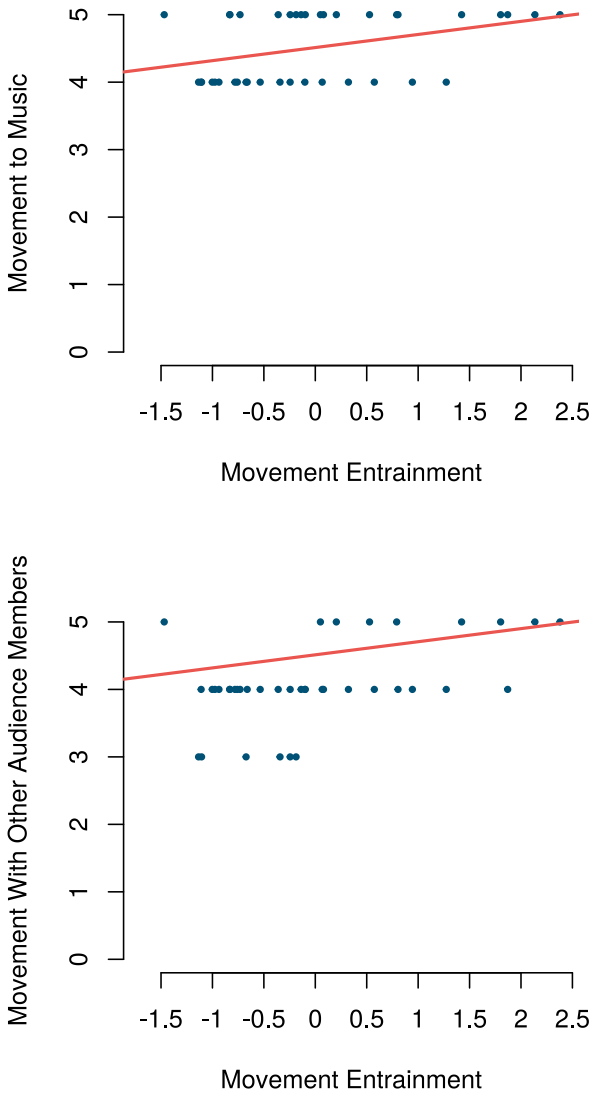


Figure E.3: Correlations between Movement Entrainment and participants' self-reports of Movement to the Music and Movement with Other Audience Members.

Table E.1: M1 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.15	38	1.81	.079
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001

Table E.2: M2 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.14	38	1.94	.060
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.37	0.13	37	2.92	.006

Table E.3: M3 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.14	37	1.93	.061
Audience (vs. Band)	–0.56	0.14	37	–4.04	<.001
Movement Entrainment	0.34	0.15	37	2.31	.026
Audience (vs. Band) × Movement Entrainment	0.07	0.14	37	0.53	.600

Table E.4: M4 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.13	38	2.22	.032
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.31	0.11	36	3.90	.006
Positive Affect	0.45	0.11	36	4.18	<.001

Table E.5: M5 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.12	38	2.42	.021
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.29	0.10	35	3.01	.005
Positive Affect	0.49	0.10	35	5.11	<.001
Familiarity With Other People in the Audience	0.32	0.10	35	3.33	.002

Table E.6: M6 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.12	37	2.41	.021
Audience (vs. Band)	–0.56	0.14	37	–4.05	<.001
Movement Entrainment	0.29	0.10	35	3.01	.005
Positive Affect	0.49	0.10	35	5.11	<.001
Familiarity With Other People in the Audience	0.27	0.12	35	2.28	.029
Audience (vs. Band) × Familiarity With Other People in the Audience	0.10	0.14	37	0.69	.494

Table E.7: M7 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.12	38	2.39	.022
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.28	0.10	34	2.82	.008
Positive Affect	0.49	0.10	34	5.03	<.001
Familiarity With Other People in the Audience	0.31	0.11	34	2.95	.006
Familiarity With the Band	0.01	0.11	34	0.11	.915

Table E.8: M8 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.11	38	2.44	.019
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.32	0.10	34	3.29	.002
Positive Affect	0.46	0.10	34	4.77	<.001
Familiarity With Other People in the Audience	0.31	0.09	34	3.35	.002
Active Musical Engagement	–0.14	0.10	34	–1.44	.159

Table E.9: M9 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.11	37	2.47	.018
Audience (vs. Band)	–0.56	0.13	37	–4.21	<.001
Movement Entrainment	0.32	0.10	34	3.29	.002
Positive Affect	0.46	0.10	34	4.77	<.001
Familiarity With Other People in the Audience	0.31	0.09	34	3.35	.002
Active Musical Engagement	–0.26	0.12	34	–2.24	.031
Audience (vs. band) × Active Musical Engagement	0.25	0.13	37	1.86	.071

Table E.10: M10 – Fixed effects of the multivariate HLM predicting Social Connection.

Predictor	*B*	*SE*	*df*	*t*	*p*
(Intercept)	0.28	0.12	38	2.41	.021
Audience (vs. Band)	–0.56	0.14	38	–4.08	<.001
Movement Entrainment	0.29	0.10	34	3.00	.005
Positive Affect	0.49	0.10	34	5.07	<.001
Familiarity With Other People in the Audience	0.32	0.10	34	3.36	.002
Age	–0.09	0.09	34	–0.95	.351

F Questionnaires for Concert Dataset 3

F.1 Pre-Concert Questionnaire

UNIVERSITÄT ZU KÖLN

Musikwissenschaftliches Insitut
https://musikwissenschaft.phil-fak.uni-koeln.de

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Martin Kreuzer: martin.kreuzer@uni-koeln.de

Liebe:r Konzertbesucher:in,
vielen Dank für die Teilnahme an diesem Experiment. Dieses Forschungsprojekt untersucht das Musikerleben im Konzert. Darum ist deine Meinung für uns wichtig. Bitte fülle den Fragebogen in Ruhe aus. Alle Daten sind anonymisiert (siehe Einverständniserklärung bzw. Infoblatt). Bei Fragen wende dich gerne an das Team. Vielen Dank für deine Mithilfe!

Code: Bitte trage hier dein Codewort ein.

Die ersten beiden Buchstaben des Vornamens deiner Mutter: ___ ___
Den Geburtstag deiner Mutter (nur der Tag): ___ ___
Deinen eigenen Geburtstag (nur der Tag): ___ ___

Daraus ergibt sich dein Codewort: ___ ___ ___ ___ ___ ___

Wie alt bist du (in Jahren)? _____

Mit welchem Geschlecht identifizierst du dich?

☐ weiblich ☐ divers ☐ männlich ☐ keine Angabe

Was war bislang der höchste Bildungsabschluss, den du erreicht hast?

☐ (noch) keinen Abschluss. ☐ Hauptschule ☐ Realschule ☐ (Fach-)Abitur

☐ Hochschulstudium ☐ Sonstiges:_____

Auf der Rückseite geht es weiter.

Nun möchten wir gerne von dir wissen, wie du dich fühlst. Die folgenden Wörter beschreiben unterschiedliche Gefühle und Empfindungen. Lese jedes Wort und trage dann in die Skala neben jedem Wort die Intensität ein. Du hast die Möglichkeit, zwischen fünf Abstufungen zu wählen. Gib bitte an, wie du dich momentan im Allgemeinen fühlst.

	gar nicht	ein bisschen	einiger-maßen	erheblich	äußerst
	1	2	3	4	5
aktiv	☐	☐	☐	☐	☐
bekümmert	☐	☐	☐	☐	☐
interessiert	☐	☐	☐	☐	☐
freudig erregt	☐	☐	☐	☐	☐
verärgert	☐	☐	☐	☐	☐
stark	☐	☐	☐	☐	☐
schuldig	☐	☐	☐	☐	☐
erschrocken	☐	☐	☐	☐	☐
feindselig	☐	☐	☐	☐	☐
angeregt	☐	☐	☐	☐	☐
stolz	☐	☐	☐	☐	☐
gereizt	☐	☐	☐	☐	☐
begeistert	☐	☐	☐	☐	☐
beschämt	☐	☐	☐	☐	☐
wach	☐	☐	☐	☐	☐
nervös	☐	☐	☐	☐	☐
entschlossen	☐	☐	☐	☐	☐
aufmerksam	☐	☐	☐	☐	☐
durcheinander	☐	☐	☐	☐	☐
ängstlich	☐	☐	☐	☐	☐

Bitte gib an, inwiefern du den folgenden Aussagen zustimmst. Bitte setze in jeder Zeile ein Kreuz.

	stimme ganz und gar nicht zu	stimme nicht zu	stimme eher nicht zu	weder noch	stimme eher zu	stimme zu	stimme voll und ganz zu
	1	2	3	4	5	6	7
Ich beschäftige mich in meiner Freizeit viel mit musikbezogenen Aktivitäten.	☐	☐	☐	☐	☐	☐	☐
Musik kann bei mir Erinnerungen an Personen und Orte hervorrufen.	☐	☐	☐	☐	☐	☐	☐

	stimme ganz und gar nicht zu 1	stimme nicht zu 2	stimme eher nicht zu 3	weder noch 4	stimme eher zu 5	stimme zu 6	stimme voll und ganz zu 7
Ich kann beurteilen, ob jemand falsch oder richtig singt oder spielt.	☐	☐	☐	☐	☐	☐	☐
Wenn jemand anders ein Lied singt, das ich kenne, kann ich eine zweite Stimme dazu singen.	☐	☐	☐	☐	☐	☐	☐
Ich bin noch nie für meine musikalischen Fähigkeiten gelobt worden.	☐	☐	☐	☐	☐	☐	☐
Musik ist für mich eine Art von Sucht – ohne sie könnte ich nicht leben.	☐	☐	☐	☐	☐	☐	☐
Ich kann beurteilen, ob jemand gut singt oder nicht.	☐	☐	☐	☐	☐	☐	☐
Ich bin in der Lage, die richtigen Töne zu treffen, wenn ich zu einer Aufnahme mitsinge.	☐	☐	☐	☐	☐	☐	☐
Ich suche oft Musik aus, bei der ich eine Gänsehaut bekomme.	☐	☐	☐	☐	☐	☐	☐
Ich kann beurteilen, ob jemand nicht im Rhythmus mit der Musik singt oder spielt.	☐	☐	☐	☐	☐	☐	☐
Ich suche häufig eine bestimmte Musik aus, um mich zu motivieren oder zu begeistern.	☐	☐	☐	☐	☐	☐	☐
Ich kann auswendig singen oder Musik spielen.	☐	☐	☐	☐	☐	☐	☐
Ich lese oder suche oft im Internet nach Dingen, die mit Musik zu tun haben.	☐	☐	☐	☐	☐	☐	☐

Bitte wenden, die Seiten sind doppelseitig bedruckt.

Nun bitten wir dich noch um folgende Angaben:

Ich habe regelmäßig und täglich ein Instrument (einschließlich Gesang) für ___ Jahre geübt.

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4–5 ☐ 6–9 ☐ 10 oder mehr ☐

An dem Höhepunkt meines Interesses habe ich mein Hauptinstrument ___ Stunden pro Tag geübt.

0 ☐ 0,5 ☐ 1 ☐ 1,5 ☐ 2 ☐ 3–4 ☐ 5 oder mehr ☐

Ich kann ___ verschiedene Instrumente spielen.

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 oder mehr ☐

Jetzt haben wir noch drei Fragen zu deinem Konzertbesuch:

Wie viele Konzerte hast du innerhalb der letzten 12 Monate besucht? _____

Wie viele davon waren Popkonzerte? _____

Bist du heute alleine oder in Begleitung gekommen? ☐ alleine ☐ in Begleitung

Hast du sonst noch Kommentare für uns?

Herzlichen Dank für die Teilnahme an dieser Studie!
Schon verkabelt? Falls nicht, hilft dir unser Team gerne weiter.
Und dann viel Spaß im Konzert!

F.2 Post-Concert Questionnaire

UNIVERSITÄT ZU KÖLN
Musikwissenschaftliches Insitut
https://musikwissenschaft.phil-fak.uni-koeln.de

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Liebe:r Konzertbesucher:in,
vielen Dank für deine Teilnahme und deine Geduld!
Mit diesem Fragebogen schließt du das heutige Experiment vollständig ab.
Bitte fülle den Fragebogen in Ruhe aus. Auch hier gilt, dass alle Daten anonymisiert werden (siehe Einverständniserklärung bzw. Infoblatt). Bei Fragen wende dich gerne an das Team.

Code: Bitte trage hier dein Codewort ein.

Die ersten beiden Buchstaben des Vornamens deiner Mutter: ___ ___
Den Geburtstag deiner Mutter (nur der Tag): ___ ___
Deinen eigenen Geburtstag (nur der Tag): ___ ___

Daraus ergibt sich dein Codewort: ___ ___ ___ ___ ___ ___

Wir möchten gerne von dir wissen, wie du dich jetzt fühlst. Die folgenden Wörter beschreiben unterschiedliche Gefühle und Empfindungen. Lese jedes Wort und trage dann in die Skala neben jedem Wort die Intensität ein. Du hast die Möglichkeit, zwischen fünf Abstufungen zu wählen. Gib bitte an, wie du dich momentan im Allgemeinen fühlst.

	gar nicht	ein bisschen	einiger-maßen	erheblich	äußerst
	1	2	3	4	5
aktiv	☐	☐	☐	☐	☐
bekümmert	☐	☐	☐	☐	☐
interessiert	☐	☐	☐	☐	☐
freudig erregt	☐	☐	☐	☐	☐
verärgert	☐	☐	☐	☐	☐
stark	☐	☐	☐	☐	☐
schuldig	☐	☐	☐	☐	☐
erschrocken	☐	☐	☐	☐	☐
feindselig	☐	☐	☐	☐	☐
angeregt	☐	☐	☐	☐	☐
stolz	☐	☐	☐	☐	☐
gereizt	☐	☐	☐	☐	☐
begeistert	☐	☐	☐	☐	☐
beschämt	☐	☐	☐	☐	☐
wach	☐	☐	☐	☐	☐
nervös	☐	☐	☐	☐	☐
entschlossen	☐	☐	☐	☐	☐
aufmerksam	☐	☐	☐	☐	☐
durcheinander	☐	☐	☐	☐	☐
ängstlich	☐	☐	☐	☐	☐

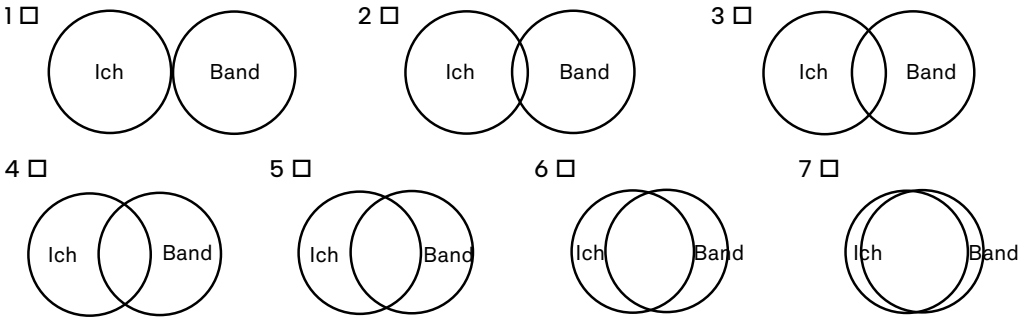
Bitte wenden, die Seiten sind doppelseitig bedruckt. 1

Wie hast du die folgenden Konzertaspekte <u>während des Hauptacts erlebt</u>? Lege auf einer fünfstufigen Skala fest, wie sehr die jeweilige Aussage zutrifft. Bitte setze in jeder Zeile ein Kreuz.

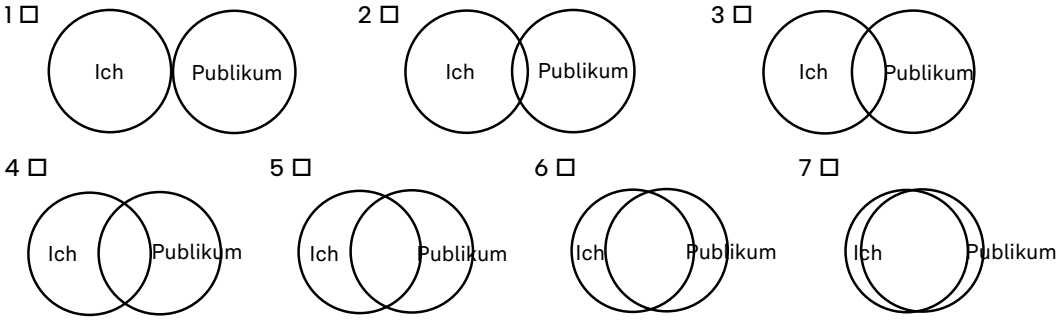
	trifft überhaupt nicht zu −2	−1	0	1	trifft voll und ganz zu 2
Musizierende und Publikum haben sich konsequent gegenseitig beeinflusst.	☐	☐	☐	☐	☐
Ich habe Schallvibrationen gespürt.	☐	☐	☐	☐	☐
Ich habe Fehler der Musiker*innen gehört.	☐	☐	☐	☐	☐
Das Musikerlebnis war für mich ein intimer Rahmen.	☐	☐	☐	☐	☐
Der Klang war ausgewogen.	☐	☐	☐	☐	☐
Ich habe etwas Einzigartiges erlebt.	☐	☐	☐	☐	☐
Das Publikum hat sich insgesamt viel bewegt.	☐	☐	☐	☐	☐
Mir war es wichtig, die/den Musizierende(n) beim Hören auch sehen zu können.	☐	☐	☐	☐	☐
Die Reaktionen des Publikums haben meine eigenen Reaktionen auf die Musik beeinflusst.	☐	☐	☐	☐	☐
Die Musik war präzise gespielt.	☐	☐	☐	☐	☐
Das visuelle Erscheinungsbild hat die Musik unterstützt.	☐	☐	☐	☐	☐
Die Musikdarbietung hat zum Tanzen angeregt.	☐	☐	☐	☐	☐
Der Klang war authentisch.	☐	☐	☐	☐	☐
Es war für mich bedeutsam, der/den/dem Musizierenden zu begegnen.	☐	☐	☐	☐	☐
Der/die Musizierende(n) hat/haben mit dem Publikum interagiert.	☐	☐	☐	☐	☐

	trifft überhaupt nicht zu −2	−1	0	1	trifft voll und ganz zu 2
Der Klang hat mich umgeben.	☐	☐	☐	☐	☐
Die Darbietung war mitreißend.	☐	☐	☐	☐	☐
Der Klang war unperfekt.	☐	☐	☐	☐	☐
Ich habe den Eindruck, dass ich den/die Musizierende(n) kennengelernt habe.	☐	☐	☐	☐	☐
Der/die Musizierende(n) hat/haben mich zum Mitmachen angeregt.	☐	☐	☐	☐	☐

Bitte beziehe deine folgenden Antworten bitte auf <u>das Konzert des Hauptacts.</u>
Bitte wähle diejenige Abbildung aus, die deine Beziehung zur Band (den Hauptact) am besten darstellt.



Bitte wähle diejenige Abbildung aus, die deine Beziehung zu den an deren Menschen im Publikum am besten darstellt.



Bitte wenden, die Seiten sind doppelseitig bedruckt. 3

Bitte beantworte auch die folgenden Fragen in Bezug auf den Hauptact. Bitte setze auch hier in jeder Zeile ein Kreuz.

	überhaupt nicht 1	2	3	4	5	6	voll und ganz 7
Wie verbunden hast du dich während des Konzerts mit der Band gefühlt?	☐	☐	☐	☐	☐	☐	☐
Wie verbunden hast du dich während des Konzerts mit den anderen Personen im Publikum gefühlt?	☐	☐	☐	☐	☐	☐	☐
Wie sehr würdest du den anderen Personen im Publikum vertrauen?	☐	☐	☐	☐	☐	☐	☐
Wie sympathisch waren dir die anderen Personen im Publikum?	☐	☐	☐	☐	☐	☐	☐
Inwieweit fühltest du dich den anderen Personen im Publikum ähnlich?	☐	☐	☐	☐	☐	☐	☐

Bitte gib an, inwiefern du den folgenden Aussagen in Bezug auf das Konzert des Hauptacts zustimmst. Bitte setze in jeder Zeile ein Kreuz.

	stimme ganz und gar nicht zu 1	stimme nicht zu 2	weder noch 3	stimme zu 4	stimme voll und ganz zu 5
Ich habe mich gemeinsam mit den Musiker*innen bewegt.	☐	☐	☐	☐	☐
Ich habe mich gemeinsam mit den anderen Menschen im Publikum bewegt.	☐	☐	☐	☐	☐
Ich habe mich zur Musik bewegt.	☐	☐	☐	☐	☐

Wie vertraut warst du mit dem Musikstil des heutigen Hauptacts?

☐ überhaupt nicht ☐ eher weniger ☐ etwas ☐ sehr

Wie vertraut warst du mit dem Hauptact?

☐ überhaupt nicht ☐ eher weniger ☐ etwas ☐ sehr

Wie hat dir der Hauptact gefallen?

☐ überhaupt nicht ☐ eher weniger ☐ etwas ☐ sehr

Wie hat dir das Konzert alles in allem gefallen?

☐ überhaupt nicht ☐ eher weniger ☐ etwas ☐ sehr

Bitte gib an, wie sehr du im Allgemeinen den folgenden Aussagen zustimmst. Bitte beziehe deine Angaben also nicht spezifisch auf den heutigen Abend.

	stimme ganz und gar nicht zu 1	stimme nicht zu 2	stimme eher nicht zu 3	weder noch 4	stimme eher zu 5	stimme zu 6	stimme voll und ganz zu 7
Wenn mich jemand fragt, ob ich tanzen möchte, sage ich normalerweise ja.	☐	☐	☐	☐	☐	☐	☐
Wenn ich mir Musik im Kopf vorstelle, will mein Körper anfangen sich zu bewegen.	☐	☐	☐	☐	☐	☐	☐
Ich finde Tanzen wirklich peinlich.	☐	☐	☐	☐	☐	☐	☐
Man muss mich normalerweise auf die Tanzfläche schleifen, weil ich nicht weiß, was ich tun soll.	☐	☐	☐	☐	☐	☐	☐
Wenn ich ein tolles Musikstück höre, muss ich einfach anfangen zu tanzen.	☐	☐	☐	☐	☐	☐	☐
Wenn ich tanze, fühle ich mich besser.	☐	☐	☐	☐	☐	☐	☐
Mit anderen Leuten zu tanzen ist eine tolle Ausgeh–möglichkeit, wenn man mich fragt.	☐	☐	☐	☐	☐	☐	☐
Ich mag es vor anderen Leuten zu tanzen.	☐	☐	☐	☐	☐	☐	☐
Ich verbringe nicht viel Zeit mit tanzbezogenen Aktivitäten.	☐	☐	☐	☐	☐	☐	☐
Manchmal habe ich das Gefühl einfach tanzen zu müssen.	☐	☐	☐	☐	☐	☐	☐
Ich würde lieber in eine Bar als in einen Club zu gehen, um nicht tanzen zu müssen.	☐	☐	☐	☐	☐	☐	☐

Bitte wenden, die Seiten sind doppelseitig bedruckt. 5

Zum Schluss bitten wir dich noch um folgende Angaben:

Wie viele der Musiker*innen des Hauptacts kennst du persönlich? ____

Wie viele Personen kanntest du im Publikum? Bitte nenne die ungefähre Anzahl: ____

Ist dein Hörvermögen eingeschränkt? ☐ ja ☐ nein ☐ keine Angabe

Hast du weitere körperliche Einschränkungen? ☐ ja ☐ nein ☐ keine Angabe

Hast du vor oder während des Konzerts Alkohol getrunken? ☐ ja ☐ nein

Falls ja: Wie viel Alkohol hast du getrunken? (Volumen Bier/Radler/Wein...) _____

Falls du auch verkabelt warst: Hast du heute Substanzen eingenommen (Beeinflussung der Messung durch z. B. Betablocker, Marihuana)?

☐ ja ☐ nein

Hast du sonst noch Kommentare für uns, auch bezüglich der Messinstrumente?

Herzlichen Dank für deine Teilnahme an dieser Studie und noch einen schönen Abend!