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EMPATHY IN MUSICAL INTERACTION

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Abstract

Entrainment has been linked to positive affect and pro-sociality, e.g. empathy. Empathy and entrainment are facets of the "shared manifold", mirroring and mental simulation system allowing us to automatically share emotions and intentions, and to understand others. They are foregrounded in music, which is very efficacious in communicating emotions and intentions. We perceive the intentional, expressive motor acts behind the sounds of music. Music therapists take advantage of this and use musical interaction to work with their clients. The cognitive foundations of synchronisation have been studied extensively, but its emotional aspects only rarely and the methods of entrainment research have only rarely been used in music therapy research, which has mainly focussed on qualitative case studies. Our aims are to study the associations between empathy, entrainment and musical communication. In dyadic tapping tasks, participants started in different tempi and later on started to hear each other's tapping. We also carried out an exploratory case study analysing the timing characteristics of a client and therapist in videos of music therapy improvisation sessions. In both cases we analysed whether and how the players entrained and the contributing factors. The link between entrainment and empathy is not linear; we discuss e.g. the effects of pair constitution and task difficulty and the characteristics of bouts of entrained and non-entrained behaviours in the music therapy session.

Keywords: interaction, music therapy, empathy

1. Introduction

People automatically and unintentionally mimic each others' body movements and gestures in conversation (Kendon, 1970; Chartrand & Bargh, 1999; Shockley, Santana & Fowler, 2003). Unintentional entrainment of body rhythms has been observed in many contexts, for example as gait entrainment between people walking side-by-side (Nessler & Gilliland, 2009), as increased body sway synchrony in conversations (Shockley et al., 2003), and in swinging pendulums and rocking in chairs (Schmidt, Carello & Turvey, 1990; Richardson et al. 2007).

Entrainment is important in all communication, but intentional entrainment is especially fore-grounded in music and dance. Interestingly for the current study, entrainment has been linked to positive affect and pro-sociality, e.g. empathy. Successful synchronisation in a finger-tapping task resulted in higher ratings of affiliation (Hove & Risen, 2009). In another series of studies, a person whose actions were mimicked was consequently more generous and helpful than controls, and this pro-social tendency was not specific to the person who mimicked them, but a more general effect (van Baaren et al. 2004).

Empathy can be seen as a multi-dimensional trait with cognitive and emotional components (Davis, 1980). Seeing the world from another person's perspective or identifying with characters in films or books are examples of the cognitive aspect of empathy (closely linked with the theory of mind), while feeling

the pain or anxiety of another person is an example of the emotional dimension (some would prefer to call this *sympathy*).

Empathy and entrainment are facets of the "shared manifold" (Gallese, 2001, 2003), the mirroring and mental simulation system that allows us to automatically and rapidly share emotions and intentions, and to understand others' actions. While present in all interpersonal interactions, they are a core feature of music and dance, two very efficacious activities in communicating emotions and intentions. Through mirroring, we perceive the intentional, expressive motor acts behind the sounds of music, and gain understanding of the underlying emotions (Overy & Molnar-Szakacs 2009). Music therapists take advantage of this and use musical interaction to work with their clients.

The cognitive foundations of rhythmic synchronisation have been studied extensively (see e.g. the classic review by Bruno Repp, 2005), but its emotional and social aspects only rarely. Also, the methods of entrainment research have only rarely been used in music therapy research, which has mainly focussed on qualitative case studies. Our general aims are to study the associations between empathy, entrainment and musical communication, using dyadic tapping studies and video data from music therapy improvisations.

2. Study 1 – Aims and methods

The aim for our dyadic entrainment study was to investigate how task characteristics such as initial tempo difference and personality and empathy factors contribute to entrainment.

A dyadic tapping experiment was conducted in two stages. In the first stage, 36 participants, 20 of whom had extensive musical training, took part. In the second stage, 38 non-musicians took part. In the first stage, participants were paired together based on their musical expertise, forming 10 musician pairs and 8 non-musician pairs. In the second stage, participants were paired together based on their perspective taking -subscale scores of the Interpersonal Reactivity Index (IRI) (Davis, 1980). This is a cognitive empathy measure. Pairs of matching high, matching low, and mixed empathy were formed.

In both stages, the tapping trials were almost identical. Participants heard a metronome click produced by a digital audio workstation through their headphones. They could also hear a woodblock sound as auditory feedback of their own tapping, as well as a different woodblock sound from the other participant's taps. The participants were producing isochronous tapping with one finger, using Roland Hand-sonic 10 MIDI drums.

Participants performed a series of 45 second tapping trials. Each trial had the same structure: the trial was started by a metronome that faded out after about 5 seconds. Participants were asked to start tapping as soon as they felt the beat, and to synchronise their taps with the metronome as accurately as possible. They were instructed to keep their original tempo as accurately as possible after the metronome faded out, and to keep tapping until they heard the end jingle (continuation tapping). See figure 1 for a schematic of the structure of the tapping trials.

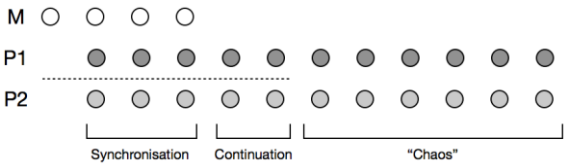

Figure 1. Structure of the tapping trials.

There were three kinds of trials. In solo trials, the participants only heard feedback from their own tapping all through the trial. In duet tasks, they started hearing their partner after 4 seconds of continuation. In same tempo trials, both participants had the same metronome in the synchronisation stage, meaning that after the synchronisation stage and a brief continuation, they entered the duet stage in very similar tempo. In different-tempo duet tasks, participants had different metronomes in the synchronisation stage, thus leading them into the duet stage in very different tempi. (We jokingly refer to this as the "chaos" stage, as two people tapping in very different tempi sounds somewhat chaotic.) In the duet tasks the instruction for the continuation and duet stages was the same as in the solo tasks: keep the

original tempo as accurately as possible, thus indicating that whenever the other participant is tapping in a different tempo, they were not supposed to synchronise with them.

Circular statistics were used to analyse entrainment between participants (Fisher, 1993; Jammalamadaka & SenGupta, 2001). Looking at tapping data as circular data means that instead of analysing the linear progression of onset times, the onset times are converted to phase angles. In this process they are related to the underlying period of the rhythm. Looking at entrainment, instead of calculating the onset time asynchronies between the participants, we calculate their relative phase at each tap, and then summarise their performance with the mean direction of these angles (e.g. whether they are entrained in-phase or anti-phase), and the concentration of this distribution, which tells us how stable this phase relationship is. Conveniently, the concentration of the distribution can get values between 0 and 1, where 0 means no consistent phase relationship, thus no entrainment) and 1 refers to perfectly stable phase relationship, perfect entrainment. Thus this concentration measure *R* is a good index for entrainment in the dyadic tapping study (Himberg, forthcoming).

3. Study 1 – Results

In *stage 1* of the experiment, we had musicians and non-musicians, and they also had filled in a personality questionnaire (Big Five Inventory, John & Srivastava, 1999). From this first stage, we learned that entrainment seems to be an on-off issue, as could be predicted from the dynamic systems studies in synchronisation (Haken, Kelso & Buntz, 1985). This is also in line with cognitivist studies of synchronisation, as once you get entrained, the automatic mechanisms of phase attraction will keep you locked in (see e.g. Repp, 2004). As figure 2 shows, musicians tend to entrain even over larger tempo differences, whereas non-musicians tend not. This could be due to the musicians having a lower tolerance for unentrained performances, as they are highly trained in playing together with others and adjust to their timing. The musicians were the better tappers, as their stability was higher than the non-musicians in all tasks (ANOVA: $F_{(1,70)} = 9.200$, $p = 0.003$, $\eta^2 = 0.116$).

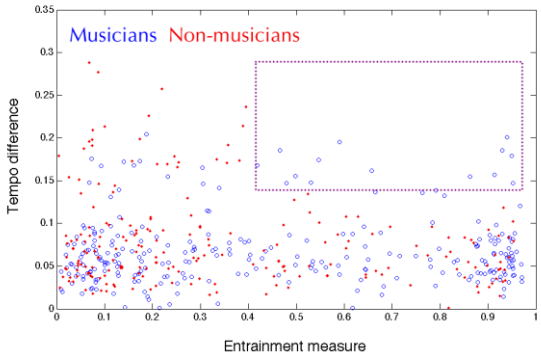

Figure 2. Entrainment measure vs. tempo difference in musicians and non-musicians, in the first stage of experiment 1. Each circle represents one trial. The purple dashed square indicates an area of high entrainment and large initial tempo difference, with only trials by musicians in it.

Logistic regression confirmed our predictions that musicianship and initial tempo difference were the most important factors in predicting entrainment. Unsurprisingly, the personality factors had no effect.

In *stage two* we modified the experiment only slightly. Mainly, we only invited non-musicians, and asked them to fill in an empathy questionnaire beforehand, so that we could form matching high and low empathy pairs as well as mixed empathy pairs. We also added more tempo combinations, so that the effect of tempo difference on entrainment could be properly statistically analysed. Also, we looked at how stabile the entrainment is in each trial by calculating a windowed entrainment analysis and looking at the standard deviation of the segment scores. Finally, we looked at how much the participants speeded up or slowed down during the chaos section and how that interacts with these other factors.

These four variables are summarised in figure 3. Looking at the stability of entrainment with-in trials (colour of the circles), this confirms our findings that it is an on-off matter, as trials that are entrained and the ones that are not (trials scoring close to 1 or 0) remain so all through, while the ones in between are the ones with more fluctuations – although there are some un-stable non-entrained trials, espe-

cially ones where the tempo drift is large. In itself, the tempo drift during the trial does not seem to have an effect on entrainment, as the range of this variable remains the same regardless of the entrainment score. This is in line with previous findings in dyadic tapping - participants can drift a lot in tempo while remaining very tightly entrained (Himberg, 2006).

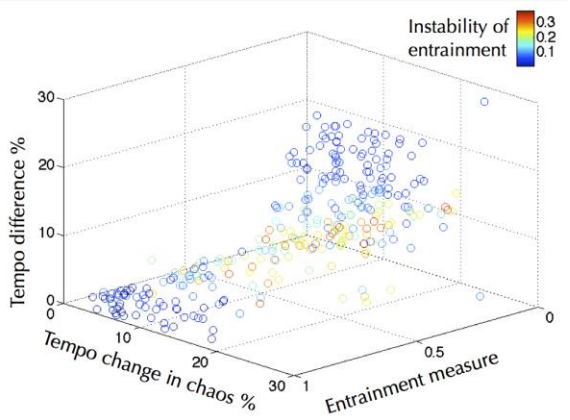

Figure 3. Entrainment measure, tempo difference at the start of the chaos section, tempo change, and instability of entrainment during the chaos section in stage 2 of the experiment.

In logistic regression, we investigated the factors contributing to entrainment. Trials were classified as "entrained" or "not entrained" using a median split of the entrainment measure. A range of variables characterising the tasks and the participants were used as predictors of class membership. Significant models were found ($X^2 = 175.2$, $p<0.0005$), with the best model classifying 81.9% of the trials correctly as entrained or not. Tempo difference was the main factor, with sum of empathy in the pair adding only a very small contribution to the model (beta<0.1).

We did not know beforehand whether it would be the individual trait or the sum across the pair, or the matchedness in the pair that would matter. Although none of these turned out to be a strong predictor of performance, it seems that it is the combined amount of whatever personality trait (Big Five or the total or individual dimensions of the IRI) that work a little better in these models than e.g. the difference in the pair or individual scores.

4. Study 1 – Conclusions

Although even simple finger tapping tasks can have a measurable effect on ratings of affiliation, and even brief encounters where gestures are mimicked can influence participants' prosocial tendencies, it seems that dispositional empathy does not have a measurable effect on entrainment in finger tapping tasks, even when the effect of it is maximised by constructing the pairs based on these scores. The task dynamics are much more important in determining synchronisation outcomes, as is musical training.

Musicians often report that they have clear preferences as to which other musicians they like to work with, and that there are clear differences in how easy it is to interact and play together with them. In the folk psychological terms, this is attributed to similarities or differences in personality. Similar differences can occur in the therapist-client relationships in music therapy. In the light of our results, we would suggest that rather than being based on personality traits or dispositional empathy as such, these differences are due to more complex combination of factors, including musical preferences and prior experiences, musical skills, communication styles, rehearsing skills etc.

5. Study 2 – Introduction

Music therapists often talk of entrainment, shared pulse and the fore-fronting of such fundamental musical characteristics in working with some client groups, those with autism among them. The reasons have been often rehearsed – before one can share much else, one needs to be able to 'share time' and attend to the same things at the same time. We now have sufficiently established methods of identification and analysis of entrainment to be able to begin to transfer these methods to the world of music therapy. In this paper we explore the precursor of such analysis through a case study exploring what questions can be asked of videos of music therapy sessions. In particular, we explore the timing characteristics of two players in a music therapy session: a client and a therapist – how much time do they

share? How much time do they not share? And what happens during these moments of shared pulse?

6. Study 2 – Aims and methods

This case study had two broad aims. The first was the exploration of the pulse characteristics of a client-music therapist pair in music therapy sessions. The second was the exploration of the context of pulse – the elements that may contribute to, and result from, different types of pulse characteristics and relationships. More specifically, we explored:

1. The distribution and length of bouts of players' regular pulse and irregular sounds throughout two music therapy sessions.

2. The distribution of bouts of shared and not-shared regular pulse (entrained and not entrained pulse)

3. The relationship between these bouts and their contexts on one hand, and behaviours that could be indicative of attention and therefore perhaps social interaction on the other.

We analysed videos of the first and third music therapy sessions from the beginning of a series of music therapy sessions with the same client (a child with ASD, in a 1-to-1 music therapy session with a Nordoff Robbins music therapist). ELAN was used for all video analysis.

We identified bouts of regular and irregular pulse (the shortest bout was 1.8 seconds long and time between beats was between 100ms and 2 seconds). We then looked at the bouts of regular pulse and identified what proportion of these contained 'shared pulse'. This was followed by an identification of where these shared pulse bouts fell in the context of the following features:

1. The bout is preceded by a clear instruction concerning what music is about to occur.
2. The bout coincides with a song with words
3. Talking 'over' the music about something other than the music
4. The client looks in musically or socially expectable directions (the instruments being played, the instruments played next, or the music therapist).

7. Study 2 – Results

There are three categories of results: (a) the characteristics of the regular and irregular moments, (b) the contexts in which we find shared and not shared pulse and (c) behaviours associated with shared pulse compared with behaviours that occur when there is no shared pulse.

The 1-to-1 music therapy sessions at Nordoff Robbins with this client group usually last about 30 minutes each. In this case total time in the room for the first session was about 16 minutes and for the second session was about 30 minutes. The total amount of time spent playing music was about 9 minutes (i.e. about 56% of the session). The total amount of time making music in the second session is about 18 minutes (i.e. about 60% of the session).

(a) Distribution and length of bouts of players' regular pulse and irregular sounds

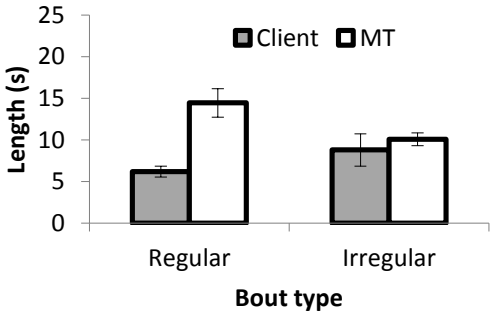

Figure 4. Bout length for Client and Music Therapist

All of the client's bouts are less than a minute (and usually less than half a minute). One of the music therapist's bouts is longer than 1 minute (Figure 4). The average length of the client's irregular bouts is longer than that of the regular bouts (and the longest two bouts are irregular). However, the total number of the client's regular bouts (50) and total time that he spends playing regular bouts (309 s) are greater and longer than the irregular ones (24 and 211 s respectively).

The music therapist has more (70) and longer (14 s average) bouts of regular pulse than the client. The music therapist has fewer bouts of irregular pulse than the client (7). However, the average length of irregular bouts

is similar for both music therapist and client (Figure 4).

The average length of bout is under 15 seconds for all categories. There are 10 longer bouts for the client (4/24 (16%) irregular bouts – two of these are the longest client bouts, and 6/50 (12%) regular bouts), 29 longer bouts for the music therapist (1/7 (14%) irregular bouts and 28/70 (40%) regular bouts).

The shared pulse bouts make up a large (80%) proportion of the client's playing time (i.e. he does not play a regular pulse on his own very much).

The shared pulse bouts last longer (7 s) and there are more of them (29) than the no-shared pulse bouts. But simultaneous no-shared pulse bouts do occur (12 times and lasting on average 4 s). There are 4 shared pulse bouts lasting longer than 15 seconds and no longer non-shared pulse bouts.

(b) Contexts in which we find shared and not shared pulse

1. We compare moments of "prearranged" music making with moments that are "not prearranged". In prearranged moments either client or therapist has given a verbal instruction relating to the type of song to play next (e.g. 'Let's play our goodbye song now'), or has given the other a musical instruction prior to the shared pulse incidence that is fulfilled (e.g. 'Come and join me at the piano…'). In moments that are "not prearranged" there was no verbal introduction to the music making.

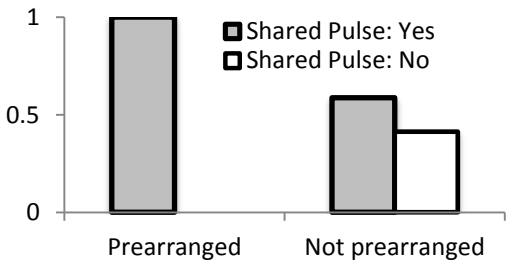

Figure 5. Proportions of shared pulse in prearranged and not prearranged situations.

We see that when the music making is prearranged there are no moments in which pulse is not shared; prearranged music making is always followed by shared pulse. However, when music making is not prearranged the music that follows may or may not include shared pulse.

2. We also compare moments of music making which includes words (i.e. either client or therapist is singing) with those that do not (music without words, i.e. no singing with words).

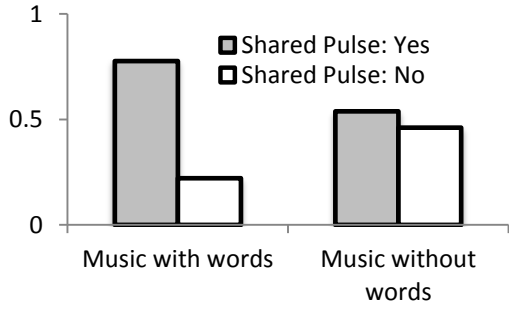

Figure 6. Proportions of shared pulse in music with and without words.

We see in figure 6 that the songs are dominated by shared pulse while those without words may or may not include shared pulse.

(c) Behaviours associated with shared pulse compared with behaviours that occur when there is no shared pulse.

Gaze direction is often taken as indicative of attention and so in this case we look at whether or not the client looks that the therapist or the musical instrument either partner is playing or the instrument the client plays next. In other words we look at musically or socially relevant looking direction.

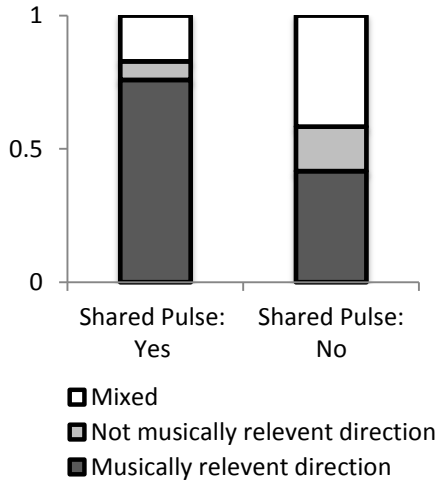

Figure 7. Proportions of gazes in musically relevant, non-relevant and mixed directions under shared and not shared pulse.

Figure 7 illustrates that musically or socially relevant looking occurs more often during the shared-pulse sections.

One of the behaviours that accompanies music making is talking 'over' the music, i.e. the client or therapist is talking about something completely different or may be related in topic but is not song like. This is compared with moments during which neither the music therapist nor client are talking at the same time as music is played. Talking 'over' the music may be seen as a contributor to the music making (and the relative pulse characteristics) or, alternatively, as a result of shared or lack of shared pulse. In the case of the former, talking over the music may be a distraction or indicator of attention. In the case of the latter, talking over the music may arise because either one of the partners or both are not focussed on the music and so begin to talk.

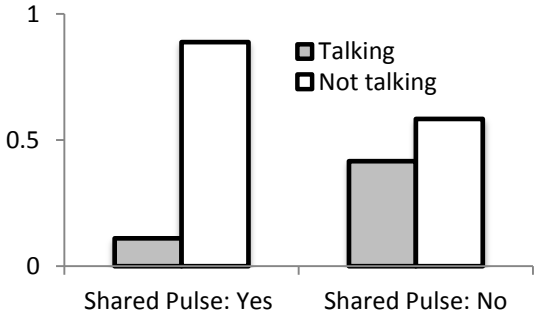

Figure 8. Proportions of talking and not talking in music with shared pulse or not.

As shown in figure 8, when there is no talking over the music, most of the music making includes shared pulse. However, when there is talking the music that follows may or may not include shared pulse.

8. Study 2 – Discussion

This case study focussed on just two music therapy sessions of the same client-music therapist pair. The total amount of time spent music making was about 56% and 60 % of the first and second session respectively.

From the beginning of the videoed sessions, it is clear that whether the client can play a regular rhythm and that whether or not he plays in time with the therapist does not seem to be physically constrained. Nonetheless, the results indicate that the average length of the client's irregular bouts is longer than that of the regular bouts but the total number of regular bouts and total time playing regular bouts are greater and longer than the irregular.

In comparison with the music therapist, the client has fewer and shorter bouts of regular pulse and more bouts of regular pulse. However, the lengths of irregular pulse bouts are similar for music therapist and client.

Putting these observations in the context of the analysis of shared pulse is telling: The shared pulse bouts make up a large proportion of the client's regular playing time; he doesn't play a regular pulse on his own very much, and playing with the therapist is associated with a greater likelihood of playing a regular pulse.

Adding in the analyses of context, we learn that there are contexts associated with shared pulse (preparing the music, and singing words with the music), while others are associated with less shared pulse (e.g. talking over the music). Finally, looking in a musically or socially relevant direction occurs more often during moments of shared pulse.

9. Conclusions

Our first study agrees with previous findings that entrainment is an automatic process and it is hard to resist. Moving from entrained to not entrained state turned out to be more like a sudden switch than a gradual transition. The first stage of the study suggested that while musicians were better in maintaining a stable pulse in general, they sometimes entrained even over large tempo differences, while non-musicians did not. This could be due to their musical training that emphasises adapting to the playing of others, and where synchronised ensemble playing is also an important aesthetic goal. The second stage further demonstrated the bimodal distribution of entrainment across tasks, and while trials with small tempo difference tend to end up entrained and those with a large difference tend to not be entrained, there is no clear threshold, but other factors seem to be at play.

In relation to task-related factors such as the initial tempo difference, personality traits had very little effect. The overall amount of

dispositional empathy in the pair was seen to contribute a little to a model that classified the trials as entrained or not. While entrainment has been observed having a measurable effect on affiliation, pro-sociality and empathetic behaviour (e.g. Hove & Risen, 2009; van Baaren et al., 2004), it seems that the effect to the other direction is weaker.

These links between empathy and entrainment are relevant for music therapy. In our first study, we tested so-called *normal* participants, while clients in music therapy often have impairments in social cognition and severe problems in connecting with others. Often clients in music therapy show great improvement in synchronisation and coordination over the course of their sessions, but a lot of the mechanisms are still unclear. To this end, we first wanted to see how often the client and the therapist play in synchrony, and under which conditions.

The second study suggested that the number of bouts and length of regular and irregular pulse differ between the music therapist and the client. The client's regular pulse occurred predominantly when it was shared with the music therapist. Certain contexts seemed to promote regular while shared pulse and others co-occurred with bouts of no-shared pulse.

Nordoff Robbins music therapists often hone in on the fleeting moments of togetherness in order to promote and develop musical interactions with their clients. As we know from the first study in this paper, players do not tend to gradually move towards or away from entrainment – there's usually a switch. A development of the current study will be to explore the non-shared moments in more detail; to identify fleeting moments of togetherness, the contexts in which they occur, and their relationships with the bouts of shared pulse. A second development will be to bring the methods of these two studies closer to capitalise on automated methods of pulse analysis. By studying a wider range of entrained behaviours (resisting it in addition to aiming for it) and by investigating its occurrence in music therapy, we hope to learn more about how music therapy works, how to measure its effects or how to predict which clients would benefit from it the most.

References

van Baaren, R., Holland, R., Kawakami, K., and van Knippenberg, A. (2004). Mimicry and prosocial behavior. *Psychological Science, 15(1):*71.

Chartrand, T. and Bargh, J. (1999). The chameleon effect: The perception- behavior link and social interactions. *Journal of personality and social psychology, 76*:893–910.

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Catalog of Selected Documents in Psychology*, 10:85–103.

Fisher, N. (1993). *Statistical Analysis of Circular Data.* Cambridge University Press, Cambridge.

Gallese, V. (2001). The shared manifold hypothesis. from mirror neurons to empathy. *Journal of Consciousness Studies, 8, 5(7):*33–50.

Gallese, V. (2003). The manifold nature of interpersonal relations: A quest for a common mechanism. *Philosophical Transactions of the Royal Society B: Biological Sciences, 358:*517–528.

Haken, H., Kelso, J., and Bunz, H. (1985). A theoretical model of phase transitions in human hand movements. *Biological cybernetics, 51(5):*347–356.

Himberg, T. (2006). Co-operative tapping and collective time-keeping - differences of timing accuracy in duet performance with human or computer partner. In Baroni, M., Addessi, A. R., Caterina, R., and Costa, M., eds, *Proceedings of the ICMPC 9*, 377, Bologna, Italy.

Himberg, T. (forthcoming). *Interaction in Musical Time.* PhD thesis, Faculty of Music, University of Cambridge, Cambridge, UK.

Hove, M. J. and Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition, 27(6):*949–960.

Jammalamadaka, S. R. and Sengupta, A. (2001). *Topics in Circular Statistics,* volume 5 of Series on Multivariate Analysis. World Scientific Publishing, Singapore.

John, O. P. and Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In Pervin, L. A. and John, O. P., editors, *Handbook of Personality: Theory and Research*, pages 102–138. The Guilford Press, New York, 2nd edition.

Kendon, A. (1970). Movement coordination in social interaction: Some examples described. *Acta psychologica, 32*:101–125.

Nessler, J. A. and Gilliland, S. J. (2009). Interpersonal synchronization during side by side treadmill

walking is influenced by leg length differential and altered sensory feedback. *Human Movement Science, 28:*772–785.

Overy, K. and Molnar-Szakacs, I. (2009). Being together in time: Musical experience and the mirror neuron system. *Music Perception, 26(5):*489–504.

Repp, B. H. (2004). On the nature of phase attraction in sensorimotor synchronisation with interleaved auditory sequences. *Human Movement Science, 23:*389–413.

Repp, B. H. (2005). Sensorimotor synchronization: A review of the tapping literature. *Psychonomic Bulletin & Review, 12(6)*:969–992.

Richardson, M., Marsh, K., Isenhower, R., Goodman, J., and Schmidt, R. (2007). Rocking together: Dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science, 26(6):*867–891.

Schmidt, R. C., Carello, C., and Turvey, M. T. (1990). Phase transitions and critical fluctuations in the visual coordination of rhythmic movements between people,. *Journal of Experimental Psychology: Human Perception and Performance, 16(2)*:227–247.

Shockley, K., Santana, M.-V., and Fowler, C. A. (2003). Mutual interpersonal postural constraints are involved in cooperative conversation. *Journal of Experimental Psychology-Human Perception and Performance, 29(2):*326–332.