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Investigating cognitive mechanisms of social interaction through musical joint action

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Abstract

Contagion, Empathy and Theory of Mind (ToM) are important social cognitive mechanisms that develop gradually in human ontogeny, enabling humans to interact with other human beings in a complex manner. However, the development of cognitive mechanisms for early social interaction is still underexplored. Therefore, the aim of the current paper is to investigate these mechanisms in a broader range from a theoretical as well as empirical perspective. In particular, we propose a music-centered approach, which allows us to investigate cognitive mechanisms of social interaction independently of children's language skills in a musical joint action setting. In our theoretical part, we delineate the social cognitive mechanisms, namely contagion, empathy and ToM. Especially, we suggest emergence of joint attention around nine months in ontogeny as a mile stone of the social cognitive development. Further, we propose that joint attentional skills scaffold empathy and ToM and are necessary to enable complex social communicative behaviors such as joint action. Our empirical part focuses on joint attentional behaviors and explores these in musical joint action of children of different age-groups (1.5–2.5 y; 3–4 y; 5–6 y) by using structured observation of video-recordings. The observation session takes place in a regular lesson of music education for young children, which includes interactive clapping, dancing and other rhythmic and musical gestures under the guidance of a tutor. Results of analyzing indicators of social interactions such as gaze following, mimicry, gestures, and intra- and inter-individual synchronization will be presented. It is claimed that investigating musical joint action provides a new possibility to explore how increasingly complex social cognitive mechanisms emerge in human ontogeny in social communicative behaviors across a wide range of age and adds to current methods in social cognitive neuroscience.

Keywords: Development, Musical joint action, Social cognition, Structured observation

1. Introduction

Almost all of us are familiar with the feeling to get involved in social interaction through music. For example, music may make you dance together with your friends, you could share an aesthetic experience with your partner, or people may play music together in an ensemble. Therefore, in our approach we avoid to reduce music to complex acoustic phenomena as often done in modern cognitive neuroscience of music and consider more important aspect of music, namely social component. Though the relevance of social components over complex acoustic features in music are pointed out by several authors repeatedly (Overy and Molnar-Szakacs, 2009; Cross, 2012), empirical investigations of music as a social domain are still in its infancy. Therefore, the main goal of our current paper is to add to this evolving research area by investigating cognitive mechanisms of social interaction through observing interactive behavior during music making. In particular, we are focusing on the development of social cognitive mechanisms in human ontogeny and their relation to children's ability to interact in a joint musical activity.

Contagion, Empathy, and Theory of Mind (ToM) are cognitive mechanisms that are crucial components to socially interact with other human beings and are claimed to develop gradually in human ontogeny (Bischof, 2008). In the current paper, we concentrate on empathy because it allows us to investigate social interaction in a much broader range than ToM which seems to be in a close relationship with the development of children's language ability (Bischof, 2008). By focusing on empathy, it is possible to explore early social cognitive development in human

ontogeny and social interaction in other domains than language, for example, in the domain of music.

The current paper consists of two parts. In our theoretical part, we first briefly point out limitations of ToM research and propose the concept of "empathy" as more promising for investigating social cognitive mechanisms that underlie joint musical activities which don't rely on language-based communication. Moreover, we relate our findings regarding social cognitive mechanisms to social communicative mechanisms: joint attention is a basis for joint action, i.e. sharing intentions and coordinating intentional behaviors between individuals. In our empirical part, we introduce one method of social cognitive neuroscience, namely observational study, as promising to investigate social cognitive mechanisms in musical interaction. We also present the setting and design of our observational study conducted in a kindergarten during a lesson of music education for young children.

2. Social cognitive mechanisms before Theory of Mind

2.1. Theory of Mind research and its limitations

In general, Theory of Mind (ToM) is the ability to infer on one's own or others' mental states and reflect upon it while being able to clearly differentiate between self and other mental states. ToM as a highly reflexive reasoning mechanism about others' mental states even seems to be uniquely human (Fitch, 2010) and appears around the age of three to four in human ontogeny (Bischof, 2008). However, the development of ToM has traditionally been investigated, for example, through using false belief tests which strongly rely on children's well developed language skills (Bischof, 2008).

The false belief test, first developed by Wimmer and Perner (1983), then modified by Baron-Cohen et al. (1985), had been a standardized task to determine whether infants can infer on other's mental states or not. In this task, also known as the "Sally-Anne test", the children have to understand a story about two characters, Sally and Anne, and reason about the belief of Sally about the position of her hidden object.[1] Regular test results show that children before the age of four years tend to fail this task by giving the wrong answer on where Sally would look for her hidden object. Researchers concluded, therefore, that at the age of four the ability of inferring on other's mental states changes fundamentally (e.g. see Wimmer & Weichbold, 1994).

However, the Sally Anne test requires several demanding subtasks emerging later in the development such as memorizing the right placement of Sally's object or understanding the final key question (Bloom & German, 2000). This test is, therefore, problematic for investigating social cognitive mechanisms in early developmental stages.

2.2. Empathy as a central concept in studying early social cognitive development

Empathy is a broad concept that has been defined very differently in the past. There are still many different definitions of empathy possible, each with its own accentuations and assumptions (Coplan, 2011). Following Coplan's (2011) definition, we propose that Empathy is a complex, high-level cognitive ability to simulate another person's mental as well as affective state, while being able to clearly differentiate between one's own and other's mental state.

2.2.1 Contagion – A primary stage

One approach investigating a primary stage of empathy is based on mirror neuron research. Mirror neurons are a class of motor neurons that were discovered in the rostral part of inferior premotor cortex in macaque monkeys and not only discharge when executing goal-directed actions like hand or mouth movements, but also when observing the same actions (Gallese et al., 1996). Such an action execution/observation matching implemented by mirror systems is often suggested to be

[1]Sally has an object and hides it in a box (e.g. a red box), and exits the room. While she is outside, Anne takes her object and places it from the red box to another (e.g. a yellow box). After listening this story, the experimenter asks the child where Sally would look for her object when she reenters the room. If the child already has ToM, the answer would be "the red box", but children without ToM would answer "the yellow box" because they fail to infer on Sally's knowledge and use their own one to answer the question.

involved in both sensory-motor and affective experiences such as predicting future action outcomes ("action simulation"; Knoblich & Sebanz, 2008:3) and understanding another's mental states (Gallese & Goldman, 1998).

In action research, the mirror systems are considered to play an important role in low-level mechanisms like motor mimicry (van der Gaag et al., 2007), which is a part of more complex mechanisms like imitation (Decety & Meltzoff, 2011). Imitation differs from motor mimicry: in imitation, agents need to understand the goals and intentions of a particular observed action, rather than just the basic motor movement (Ward, 2012). Development of imitation based on the intentions and goals of an agent can be observed in experiments in infants as young as 12 months (Schwier et al., 2006) and 14 months (Gergely et al., 2002).

Motor mimicry builds a basis of (emotional) contagion, i.e. the tendency to assimilate an affective state (Singer & Lamm, 2009). This mechanism exists early in the ontogenetic development (Bischof, 2008). For example infants that hear the cry of other infants are in return more likely to cry themselves (Simner, 1971), they adopt the affective state of another without separating between one's own and the other's affective state. Just as motor mimicry, this low-level mechanism is innate and uncontrollable by the infant. Because motor mimicry and contagion yield low-level, automatic intersubjective link, they are regarded as the "Big and Little Sisters of Empathy" (Singer & Lamm, 2009) as well as "a basic building block of empathy" (Decety & Meltzoff, 2011, p. 17).

2.2.2. Development of self-other differentiation

In human ontogeny the ability to differentiate self from others develops in a gradual manner. Contagion facilitated by motor mimicry is one of the first observable social mechanism, which doesn't require any separation of one's own and other's mental and affective states (Bischof-Köhler, 1989). The separation can be only achieved by higher levels of reflexivity which emerges in the course of ontogenetic development. The first step is the emergence of the "like me" stance, whereby infants can attribute intentional behavior to others (Decety & Meltzoff, 2011). Infants realize a specific similarity between them and other people, and transfer their own experiences regarding action-outcome relations to others (Tomasello, 1999). This new ability gets visible through joint attentional interactions such as gaze or point following (Tomasello, 1999). Joint attention marks the beginning of intersubjectivity and thus scaffolds the development of more elaborative social cognitive mechanisms.

The next step of reflexivity enables a clear self-other differentiation in mental and affective states, which is crucial for empathy and gives rise to the sensation of, for example, schadenfreude, i.e. experiencing affective states differing from the other's. To understand the boundaries which distinguish the inner mental states of others from one's own, it is necessary to have an objective view on oneself. Children, up to two years of age, experience their self as the center of own activity (Bischof-Köhler 1989, Bischof 2008). As mentioned above, they are able to attribute intentional behavior to animate objects, by drawing an analogy between themselves and other people (Tomasello 1999). However, not before two years of age this perspective gets extended by the ability to consider the self as an object of representation (Bischof-Köhler, 1989). The development of such a concept of self goes along with the emergence of the ability to recognize oneself in the mirror, i.e. the ability to recognize that 'I' am now identifying 'me' in the mirror (Bischof, 2008).

3. Social communicative mechanisms: Joint attention and joint action

In order to investigate the emerging social cognitive mechanisms as well as the development of self-other differentiation in early social interaction, we need to turn to skills of social interaction which are observable in an empirical setting. Here, we especially focus on joint attention and joint action which, we think, are of great importance in the empirical investigations of social communication and interaction.

Joint attention is a whole complex of skills (joint attentional skills) emerging in human infants between nine to twelve months of age (Carpenter, Nagell, Tomasello, 1998). As mentioned above, the emergence of joint attention is linked to the emergence of the capacity to view other people as intentional agents (Tomasello, 1999) and builds a

significant basis for the further social cognitive development. The infants' behavior shifts from dyadic interactions (i.e. infants' interaction with objects or people) to triadic social interactions (i.e. infants' interaction with people via jointly attended objects). The fundamental skills for this new social behavior includes gaze following, joint engagement, social referencing, imitative learning, directing adults' attention and behavior (differentiating imperative and declarative gestures) (Tomasello, 1999). These skills can be summarized into more general categories of "checking attention", "following attention" and "directing attention", while they are proposed to emerge ontogenetically in this general order (Carpenter, Nagell, Tomasello, 1998).

Joint action is defined as social interactions where individuals coordinate their actions to bring about a change in the environment (Knoblich and Sebanz, 2008). The flexible inter-individual coordination of movements in music can be investigated within four scenarios based on increasingly complex mechanisms of social interactions as introduced by Knoblich and Sebanz (2008). Scenario 1 focuses on "social couplings between 'socially blind' individuals" through entrainment (reciprocal interaction) and simultaneous affordance (interaction through objects which have the same affordance for the actors) (p. 2). Scenario 2 comprises simulation of intentional action in others through perception-action coupling. Mirror neurons are considered to provide a neural basis for the direct perception-action link enabling simulation. Scenario 3 deals with shared perceptions between actors through joint attention and the ability to keep own perception distinguished from another's. Scenario 4 addresses the way to form joint intentionality (intention to act together) in joint action by recognizing the other as an intentional agent, simultaneously distinguishing own intentions from another's, and relating them to each other. The mechanisms involved in these different scenarios differ in the extent to which an intentional process is involved and actors are able to keep their own intentions separated from others'.

Joint attentional skills and joint action is behavior we can observe in an empirical setting. The investigation of joint attentional skills is promising because they act as fundamental social interactive skills building the basis for higher level cognitive mechanisms like empathy and ToM. In addition, musical joint action is a complex social activity involving many motor and social skills like temporal accurate motor acts for synchronization, imitation, learning, shared understanding, prediction, encouraging eye contact, smiling, laughter and relationship building (Overy & Molnar-Szakacs, 2009). Because different scenarios of joint action reflect the development of self-other differentiation discussed in section 2.2.2., the study of interactive behaviors in musical context may provide near insight into social cognitive development of children.

4. Testing social cognitive ability before Theory of Mind

4.1. State of the art

As pointed out above (see section 2.1.), the classical investigation of social cognitive mechanisms, especially ToM, is using false believe test calling for children's highly developed language skills, which makes it difficult for children before three to four years of age to pass this test. However, as discussed above (see section 2.2.), even children without ToM possess social cognitive mechanisms, which get more reflexive in the course of the development. Those mechanisms such as contagion and empathy enable children to interact with others in a social communicative context, i.e. in a joint action. To investigate this early stage of social cognitive development, it is important to analyze children's non-verbal social behavior. In the following, we review studies examining children's ability to infer on other's mental states, particularly showing the importance of nonverbal communication such as pointing gesture and joint attentional skills like gaze following.

In O'Neill (1996) the subjects, two-year-old children, are introduced to a toy, which is later placed out of reach on a high shelf. There are four trials, two in which the parent can witness the displacement, and two in which the parent cannot. The key task is for the children to ask their parents to retrieve the toy. When the parents were not able to perceive the experimenter, placing the toy out of reach, the children would try to ask their parents for help

(e.g. toy and location naming as well as pointing gesture to location) significantly more often. This result indicates that children, younger than four years old, in fact do have knowledge of other's mental states.

An even more subtle option for examining a child's ability of reasoning about other's mental states is possible by observing gaze length and gaze direction. Onishi & Baillargeon (2005) present a nonverbal false belief task, carried out with 15-month-old children. The researchers examined the children's inferring on other's mental states via gaze duration. As presumed, the children's gaze duration was reliably longer, when the expectation of where the actor would look for the toy, was violated. This result indicates that even 15 months old children infer at least something from other's mental states.

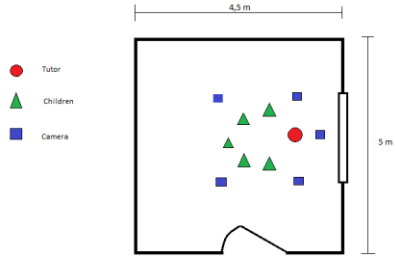
These two studies show how social cognitive mechanisms before ToM can be successfully studied by focusing on non-verbal communicative behaviors. For our study we concentrate on social interaction in a musical joint action setting, therefore analyzing indicators of joint attentional skills like gaze following or body movements. This approach offers the most direct approach to investigate these mechanisms as outlined further below.

4.2. Observational study

The main goal of our study is to draw conclusions on the development of social cognitive mechanisms through observing behavior of non-verbal communicative skills in a musical joint action setting. This will be done through an observational study. Our decision on using observational measurement compared to other measurement methods is based on three benefits of this method outlined by Bakeman & Quera (2012). First, non-verbal behavior which is the main focus of our study is best studied within the context of an observational study. Second, an observational session is proposed to result in more natural behavior by the subjects than in an experimental setting. Third, an observational study enables us to investigate processes. In our case social communicative behaviors that unfold in time. Therefore, observational study facilitates research of social interaction in an ontogenetically broad range including non-verbal children.

The observational sessions take place in the „Fröbel-Kindergarten Regenbogen“ (Cologne, Germany) in a regular lesson of music education for young children. Children from the age of 1,5 to 6 take part in our study. Participants are grouped into age-matched groups (1.5–2.5 y; 3–4 y; 5–6 y). Each group consists of four to five children. The environment is well-known to the participating children in so far as they visit this institution on daily basis and they are familiar with both the tutor who conducts the sessions and the room the session is taking place. The participants are also used to the musical content as well as the instruments. The musical content concentrates on rhythmic patterns, motor abilities, and coordination, tested through the following types of exercise. Each session takes 30 minutes.

The observational sessions are recorded with five cameras. One camera placed in each corner of the action space (and the spare one placed behind the tutor) (see figure below).



Recorded materials are later coded by using coding schema that define which events are being coded and which categories or distinctions have to be considered (Bakeman & Quera, 2012). The coding schema will be gaze following and interactive behaviors such as imitation and synchronization. The development of motor-skills, language as well as social behavior and interaction is controlled by a standardized questionnaire.

6. Conclusion and future perspectives

Theory of Mind is a well-studied field inside social cognitive science that granted an insight into the social development of children. There is still a problematic and unclear relationship between language and ToM which led us to propose a music centered approach and concentrate on ontogenetically earlier social cognitive mechanisms. Therefore, we put social cognitive mechanisms before ToM like contagion and empathy at the center of our

current paper and emphasized the emergence of self-other differentiation as crucial in the social cognitive development. In order to study social cognitive mechanisms in a broad range, we focused on non-verbal social communicative behaviors, i.e. joint attention and joint action. We hope that through analyzing non-verbal social behavior in our presented observational study using musical joint action stetting, we can draw conclusions on the general development of social cognitive mechanisms before ToM and add to research area of social cognitive neuroscience.

Moreover, the investigation of social cognitive mechanisms within musical joint action could be also applied in autism research. Individuals with autism are known to have deficits in ToM (Baron-Cohen, Leslie, & Firth, 1985) as well as in its putative precursor abilities (Baron-Cohen, 1987). Given the social nature of music, it may be promising to compare children with and without autism in our presented observational study using musical joint action setting.

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