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Affective resonance and social interaction

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Abstract Interactive social cognition theory and approaches of developmental psychology widely agree that central aspects of emotional and social experience arise in the unfolding of processes of embodied social interaction. Bi-directional dynamical couplings of bodily displays such as facial expressions, gestures, and vocalizations have repeatedly been described in terms of coordination, synchrony, mimesis, or attunement. In this paper, I propose conceptualizing such dynamics rather as processes of affective resonance. Starting from the immediate phenomenal experience of being immersed in interaction, I develop the philosophical notion of affective resonance to refer to a dynamic entanglement of moving and being-moved in relation.

The concept of affective resonance makes visible that the interaction dynamic itself creates an affective experience rather than transmitting internal feeling states between pre-existent individuals. This leads to a philosophical framework in which relationality and ontogeny are primary over separate individuals, and in which the naturalistic distinction of a fundamental physical level versus an emerging level of social processes has to be given up.

Keywords Resonance · Affect · Interaction · Ontogenesis · Social cognition · Coordination · Dynamical systems theory · Gilles Deleuze · Daniel Stern

1 Introduction

In this paper I introduce the concept of affective resonance to describe relational and processual aspects of emotional experience. Affective resonance refers to processes of social interaction whose progression is dynamically shaped in an entanglement of moving and being-moved, affecting and being-affected. This affective interplay is experienced by the involved interactants as a gripping dynamic force, which is highly sensitive to the concrete relational and situational configuration. It is a key characteristic of affective resonance that its concrete processual unfolding is an irreducible

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product of the relational entanglement and cannot be broken down to individual behavior or individual affections in the sense of 'inner feeling states'.

Affective resonance is a subtle and partial phenomenon, pervading most face-to-face social interaction. Observations such as a mutual attunement in facial expressions and gestures, or in melody, intonation and accent of language during a conversation are elementary cases. Conceptualizing them as instances of affective resonance makes visible that they are more than mere imitation or synchrony. In resonance, the interactants' behaviors and affective experiences may not necessarily resemble each other, but yet they are a *jointly created* dynamic, shaped within the relational interplay.

Even more explicit is the example of being "drawn into euphoria on an exuberant party, amongst a crowd of enthusiastic dancers whose dynamic movements and overflowing excitement literally take hold of our lived body, making us move in the rhythm of the crowd, feeling immersed and connected." (cf. Slaby 2014, 35). Conceptualizing this scenario as an instance of affective resonance allows to see it as an open process, shaped by potentials arising continuously within the relational configuration itself. The decisive point about the exuberant dance party is that it might make you act and feel in a way which goes beyond the space of individually 'possible' or pre-conceivable action.

Although the concept of resonance has its origins in physics, in this paper I propose adopting it in a transposed form as a *philosophical* notion to describe a mode of social interaction. In order to develop a thorough philosophical account of affective resonance that yet remains aware of its interdisciplinary references, I will take up related approaches in theories of interactive social cognition and in developmental psychology. Moreover, I will recall paradigmatic examples of resonance in classical physics and I will draw on selected theoretical components in the writings of Henri Bergson and Gilles Deleuze to conceptualize an immanent and creative understanding of the processuality of resonance interactions.

Dynamical approaches in interactive social cognition theory will be the main reference point in this paper (De Jaegher and Di Paolo 2007; Di Paolo et al. 2007; Thompson 2007; Thompson and Varela 2001). They offer an understanding of the irreducible dynamical entanglement in social interaction based on notions from the mathematical theory of dynamical systems. As I will point out, this implies that most of these approaches commit to a naturalistic framework, in which resonance is reduced to the external and statistical notions of "coordination" and "correlation". I will argue in sections 2.1 and 2.2 that this fails to grasp the immediate phenomenal quality of being-in-resonance.

Approaches in developmental psychology also deal with phenomena of dynamic (bi-directional) interaction. A good example is Daniel Stern's (1985) notion of "affect attunement". Stern uses this concept to refer to a dynamic mode of interaction in the infant-caretaker dyad, consisting of cross-modal synchronization (or quasi-synchronization) in timing, rhythm and intensity contours of affective displays (facial, vocal, bodily movements). Stern points out that this generates a sphere of "shared" affective experience, connecting infant and caretaker. But as I will argue in section 2.6, his own theorization remains bound to an ontology of "inner feeling states" of independently existing individuals, which reduces the dynamic phenomenon of affect attunement to a mere mode of "transmission" and "sharing". In consequence, Stern's account does not describe in full depth that the interaction dynamic itself *creates* and *constitutes* an affective quality which is not pre-existent to the encounter.

As an overall consequence, I will depart from the referenced scientific approaches by switching to an immanent perspective of theorization. We need to take seriously the phenomenal qualities of being-in-resonance, experienced as a gripping dynamic force of moving and being-moved in relation. To avoid an ontology of independently constituted individuals and internal feeling states, I will anchor the conception of affective resonance in a framework taking relatedness and processuality as ontologically primary. In this relational ontology, the individual will be accounted for in a sense of *ontogeny,* as an individual always in relation and always in becoming within a relational-processual realm of affective resonance.

2 The concept of affective resonance

Scholarly work focusing on the formation of emotional experience in interpersonal and dynamic processes has recently been advancing along different lines in areas ranging from cognitive sciences of emotion to sociology, phenomenology, and affect studies. Within the more science related approaches, one major trend of the last two decades has been inspired by the mathematical field of dynamical systems theory. Centering around a concept of emergence, these theories account for social and emotional processes as arising from an underlying level of physical micro-interactions (cf. De Jaegher and Di Paolo 2007; Di Paolo et al. 2007; Thompson 2007; Thompson and Varela 2001). I begin this section by taking up one of the most important approaches within this paradigm, which is the branch of interactive social cognition theory in the borderland between cognitive science and phenomenology.

2.1 "Coordination" in interactive social cognition and participatory sense-making

The so called "interactive turn" in social cognition research has been highlighting the primacy of intersubjective relatedness of the newborn (see Gallagher 2008, 2009; Hutto 2004) and the constitutive relevance of embodied social interaction through gestures, movements, and facial expressions to social understanding (see Krueger 2011). Generally, interactive social cognition is operating within the "enaction paradigm", a branch in cognitive science which is, in opposition to more traditional, cognitivist and computational accounts, approaching cognition as a situated, embodied and self-organizational activity in the world (Thompson 2007; Varela et al. 1991; Noë 2004). Concrete conceptualizations of this world, however, often remain phenomenologically simple and abstract, and most notably, they are lacking a proper sense of *social* situatedness. Taking the world as a social world and the cognitive being as a social one, a shift from action to interaction is necessary, as is recognized by the proponents of the "interactive turn" (see De Jaegher et al. 2010; De Jaegher 2009; Gallagher 2001; Hutto 2004; Ratcliffe 2007; Reddy 2008). And here, finally, it depends crucially on the exact notion of social interaction, whether the resulting theoretical framework is really succeeding in its attempt to account for the socio-cultural situatedness of the subject (see also De Jaegher, Di Paolo 2007, 486, 494).

Within this theoretical context, the article on "participatory sense-making" by Hanne De Jaegher and Ezequiel Di Paolo (2007) marks an important step towards an understanding of how "sense" and "meaning" are jointly constituted in processes of

social interaction. This contribution is of particular relevance to the present paper as it suggests an account of social qualities as irreducibly co-constituted in relation. This relational co-constitution is meant to involve other social agents and present environmental structures (synchronic relatedness), but also the history of interactions (diachronic relatedness). In order to develop this relational and dynamical account of social qualities, De Jaegher and Di Paolo present a conception of interaction based on concepts borrowed from dynamical systems theory (cf. 490). Dynamical systems theory is a generic mathematical framework studying the behavior of formal "systems" given by a time-parametrized *state function* and a *differential equation* determining the system's time evolution.[1] It is both well known from a theoretical standpoint and well observed in physical and biological examples that if two dynamical systems are coupled,[2] their joint behavior may display a phenomenon called "coordination". De Jaegher and Di Paolo explain coordination as a "non-accidental correlation between the behaviors of two or more systems …", for instance, a synchronization in their movements, as in the famous example of the two "[p]endulum clocks, … synchroni[zing] their oscillations when in each others' vicinity through the minute vibrations they provoke on the wall" (490).

This mathematical notion of coordination is at the core of the understanding of interaction in participatory sense-making. According to De Jaegher and Di Paolo, it "allows us to view interactions as processes extended in time with a rich structure that is only apparent at the relational level of collective dynamics" (490). The theory of participatory sense-making then goes on to propose that from this relationally constituted "structure" on the level of coordination patterns there arises, as an *"emergent" level,* an "autonomous" process of maintaining the social encounter. On this emergent level, "patterns of coordination can directly influence the continuing disposition of the individuals involved to sustain or modify their encounter", and, in the converse direction, "the interactors … are susceptible to being affected by the history of coordination." It is this "double influence"—"from the coordination onto the unfolding of the encounter and from the dynamics of the encounter onto the likelihood to coordinate"—that makes, according to De Jaegher and Di Paolo, the interaction a *social* interaction (492). And it is on this emergent level of coordination dynamics in social interaction that also "the sense-making of interactors acquires a coherence through their interaction". As part of the emergent autonomous processes, individual sense-making processes are dynamically coupled to form a "joint process of sense-making" (497), so that "sense" and "meaning" are participatorily constituted in interaction as an "emerging quality" irreducible to partial processes located in separate interactants.

[1] A "dynamical system", which is the name of the formal mathematical object under investigation in dynamical systems theory, is typically comprised of a time-parametrized *state function* and a system of *differential equations* determining the state function's temporal evolution based on its current value and higher order derivatives. The value of the state function could be, e.g., a vector of real numbers, describing the current configuration of the system at a given point in time. Adopting this framwork thus implies, in particular, that the system under consideration (in our case: the cognitive being, or its putative mathematical formalization as a dynamical system) is of such a kind (or can be mathematically formalized in such a way) that *its configuration at each point in time can be represented by an element of a certain pre-fixed configuration space.* See, for instance, Katok and Hasselblatt 1997, 1–6.

[2] Coupling of two or more dynamical systems means that they are in some sort of ongoing causal interaction, which is formalized by a mathematical coupling of their respective differential equations of evolution.

The notion of "emergence" is central to dynamical systems theory (cf. Corning 2002) and to the embodiment paradigm in cognitive science (Varela et al. 1991; Thompson and Varela 2001; Thompson 2007; see also Protevi 2009). As Di Paolo, Rohde, De Jaegher (2010) specify,

> Emergence is used to describe the formation of a novel property or process out of the interaction of different existing processes or events (…). In order to distinguish an emergent process from simply an aggregate of dynamical elements, two things must hold (1) the emergent process must have its own autonomous identity, and (2) the sustaining of this identity and the interaction between the emergent process and its context must lead to constraints and modulation to the operation of the underlying levels. (40).

Writing this, they have in the background the more formal definition given by Thompson and Varela (2001):

> A network, *N*, of interrelated components exhibits an emergent process, *E*, with emergent properties, *P*, if and only if:
>
> (1) *E* is a global process that instantiates *P* and arises from the nonlinear dynamics, *D*, of the local interactions of *N*'s components.
>
> (2) *E* and *P* have a global-to-local ('downward') determinative influence on the dynamics *D* of the components of *N*. (420)

Emergence, following these definitions, comes with a qualitative leap along a hierarchy of scales. The arising novel quality is a *global* process with an "own autonomous identity", sustained in "operational closure" and interacting within its own (global) realm. It is brought about, as a whole, from a *substratum* of "local interactions". This transition, reaching from a substratum to a global level, is often referred to as "local-to-global determination" or "upward causation" (Thompson and Varela 2001). Complementary to this, there is also a "downward" causal feedback from the emergent realm onto the substratum. The "autonomy" of the emerging global process causes a "global-to-local ('downward') determinative influence", which may lead to "modulations to the boundary conditions of the lower-level processes" (Di Paolo, Rohde and De Jaegher 2010, 40–41; Thompson and Varela 2001, 420–421).

Now, in a "naturalistic project" such as the theory of participatory sense-making, the substrate level is modeled in an ontology of classical or contemporary physics—it is conceived as *local causal interactions* of physical entities.[3] Social qualities, in contrast, are seen as emerging higher order processes. These processes exist in a realm which is not completely causally independent but yet *logically separate* from the fundamental level of physical micro-dynamics. On their own level of emergence, social qualities maintain a "self-generated identity" and follow their "own laws of transformation" (Di Paolo, Rohde, De Jaegher 2010, 37–42). In this way, the adopted understanding of emergence implies an

[3] See Di Paolo, Rohde and De Jaegher 2010, 40. See also Thompson and Varela 2001; and De Jaegher, Di Paolo 2007, 487, where "the encative perspective" is called "a kind of non-reductive naturalism".

ontological hierarchy which is at the same time a local–global hierarchy. It implies a distinction of the "physical" and the "social" as different processual levels, whereby the physical level is ontologically fundamental and the social level is derived.[4]

2.2 Towards an immanent perspective on social interaction

Besides this ontological hierarchization, the assumed understanding of emergence in the theory of participatory sense-making implies also a specific *epistemological* stance. The description of an emergent process as a global whole, arising from underlying substrate processes, but maintaining "operational closure" and a "self-generated identity" relies on an external perspective both upon the substratum and upon the emerging realm. Thus, the mentioned ontological hierarchy of emergent processual levels is at the same time a hierarchy of parallel levels of *theorization,* each relying on a disengaged total perspective upon the phenomenon (cf. also De Jaegher, Di Paolo 2007, 486). As a consequence, participatory sense-making inherits an epistemological standpoint from which it is objectifying the phenomenon of social interaction both—and separately—with respect to 'physical' and 'social' qualities. In describing the interaction process as an "entity" that "emerges … when social encounters acquire [an] operationally closed organization", De Jaegher and Di Paolo intend to constitute "a level of analysis [which is] not reducible, in general, to individual behaviours" (492). This level of analysis is indeed irreducible, but more than that does it turn social interaction into a holistic pattern which is apparent only from an outside angle. It seems that the reach of this analysis is limited to an external third-person-perspective, breaking down the phenomena into correlations and pattern matching in the temporal evolution of state functions.

How is social interaction *experienced* from an immanent perspective, i.e., from a vantage point located *within* the processual engagement itself? How does a processual-relational dynamic such as coordination become manifest as a perceivable quality inherent in the social encounter?—For a moment still speaking in the old polarization of a 'physical' vs. a 'social level', one could say that emergent qualities are immanently manifest to the involved individuals by "downward causation", i.e., by the local constraints induced upon the substrate processes by the emergent global process. But this account would make the immanent manifestation of being-in-coordination a derived and secondary quality although it is in fact *the primarily experienced phenomenon.* As a consequence, I propose in this paper taking it as the starting point of theorization. I am looking for an epistemic shift away from the external perspective towards an *immanent processual-relational* account of social interaction. This shift is characterized by the following two chief aspects.

First, the notion of "coordination" itself is problematic as long as it is understood as a "non-accidental correlation between the behaviors of two or more systems" (De Jaegher, Di Paolo 2007, 490). Following this definition, coordination is a descriptive finding of matching temporal patterns of state functions. It relies on an external and comparative

[4] In fact, there are more than two levels of emergence. Emergence leads from an ontologically fundamental, local and physical level to intermediate biological levels, to global, social and societal levels. See Di Paolo, Rohde and De Jaegher 2010, 40: "There is also a demand for emergentist explanations in biology, in which hierarchical organization is all too evident (e.g., genetic regulation, cells, extracellular matrices, tissues, organs, organism, dyads, groups, institutions, societies)."

perspective upon the totality of the systems from which such a correlation can be discerned. In shifting to the concept of resonance in sections 2.4 and 2.5, I will conceive of being-in-coordination as a joint dynamic which is an unfolding of *forces* that are arising within the relational configuration. This will allow me to address the same range of phenomena but from an immanent perspective as a dynamical entanglement of moving and being-moved in relation, which is directly perceivable as a force that 'takes hold of oneself.'

Second, it is a possible caveat that speaking of immanently perceivable qualities of being-in-relation implies a pre-existing perceiving individual. To prevent this misunderstanding, we have to conceptualize the individual itself in a processual and relational ontology, that is, in a framework of *ontogenesis.* The epistemic shift towards an immanent processual and relational perspective entails as well an ontological shift, taking being-in-relation and being-in-process as ontologically primary. The subjectivity experiencing resonance as an immanent quality of being-in-relation is then itself an *effect,* constituted within an ontogenetic realm of processes and relations.

However, the central core of an immanent and ontogenetic understanding of resonance in social interaction is to spell out the notion of resonance in a primary ontology of forces instead of correlating state functions. Before turning to this point in section 2.4, a deeper look at the physical origins of the notion of resonance in the next section will reveal that already in classical physical theory itself, resonance is immanently a dynamic interplay of forces, an entanglement of moving and being-moved in relation, which is constitutive of qualities beyond mere coordination.

2.3 Examples of resonance in classical physics

The most elementary scientific instances of resonance can be found in the physics of mechanical and acoustical vibrations as studied in classical mechanics, such as a guitar string, a swing pendulum, or a stationary sound wave in a shower cabin. In the context of such oscillatory systems, *resonance* is the name for the following observed phenomenon: *The degree to which an oscillatory system can be induced to oscillate by coupling it to an external periodical force (*e.g.*, to another vibrating system) is highly sensitive to the frequency of the external force.*[5] For example, the degree to which a child sitting on a playground swing can be made swinging depends on the frequency of the periodical pushes exerted by another person or by the child's pumping her own legs. Usually, there is one specific frequency (called *resonance frequency;* more complex systems may also have several resonance frequencies), at which a system can much easier be induced to oscillate than at other frequencies. One speaks of a state of resonance if the frequency of the external force matches the resonance frequency of the system, and as it turns out, it is characteristic of this state that a minimum of vibrational energy of the external force suffices to accumulate a high amount of vibrational energy inside the vibrating system. This means that resonance is a very specific and selective case of interaction where least effort takes greatest effect in terms

[5] In most physics textbooks, this notion of resonance is introduced in the context of "forced oscillations", see e.g. French 1971, Ch. 4; Morse 1948, Ch. II; Tipler 1999, Ch. 14.

of induced vibration. If the external force meets the individual resonance frequency of the system, the system's resonance seemingly "amplifies" the vibrations of the external force.

The following examples[6] help to illustrate this point: 1. There are certain frequencies at which the vibrations of a motor in a car or the spinning drum of a washing machine causes another nearby object to co-vibrate. This co-vibration only happens near the resonance frequency of the co-vibrating mechanical system. If the spinning drum goes on spinning faster or slower, the resonance vanishes at once. 2. Singing in front of a guitar causes the strings of the guitar to vibrate, but only if the frequency of the voice matches a resonance frequency of one of the guitar strings (i.e., when singing an A at 440Hz, the A-string of a tuned guitar starts co-vibrating, which is well audible if the guitar has a big resonance body additionally amplifying this vibration through resonance in stationary sound waves). 3. Shouting or singing in a small room of cubic shape, such as a shower cabin or an empty staircase, sometimes causes acoustic resonance which is easily noticed by its amplification effect: with very little vocal energy it is possible to create a much louder sound than without the resonance (e.g., in a bigger room, in a well-damped room, or outdoors). A stationary sound wave between the walls is an acoustic system with several resonance frequencies that gets excited by the singing voice, amplifying it to its multiple in amplitude as vibrational energy gets accumulated in the stationary wave.

These examples show that mechanical/acoustical resonance presents a constellation in which the vibrations of a system A induce vibrations of a system B in such a way that system B's co-vibration creates the effect of an amplification compared to the situation where either A is vibrating at a different frequency (so that B would not resonate) or where A is vibrating without coupling to B.[7] This effect is most paradigmatic in the cases of singing in a shower cabin, or of the sound of a guitar string being amplified in resonance coupling to the stationary wave in an acoustic guitar's resonance body. But in fact, this effect is not only one-way, but bi-directional: In the case of the guitar string, the amplification does not only consist in the vibration of the stationary wave in the resonance body adding volume to the strings' own vibration. But the vibration of the string itself, after being plucked, lasts longer (fades out slower) compared to a guitar without resonance body. This is because not only does the vibration of the string resonate in a stationary wave in the body. But the stationary wave in the body *at the same time* re-induces a resonance vibration of the string. This is the decisive qualitative feature of resonance: it is a co-dependent *interplay* of the two coupled systems, it is something that is dynamically established in the coupling as a bi-directional and non-additive joint process. 'Non-additive' means that the vibration in

[6] For an exhaustive collection of examples in the context of the related but slightly different notion of "synchronization", cf. also Pikovsky et al. 2001.

[7] More precisely, "amplification" here denotes the formal observation that in resonance, the amount of energy per time kept inside the coupled system as vibrational energy instead of being lost to the environment or into other forms of energy is at a local maximum. It then takes less power for the excitator to reach a certain resonance amplitude in effect. This means that the amplification effect is apparent only when the external force is not idealized as an infinite reservoir of energy but when its power is of comparable order to the amount of vibrational energy per time stored in the resonating system (such as in the case of singing in the shower).

resonance is not a linear sum of separate vibrational contributions of the two coupled systems. It is not a superposition of independent processes in A and B, but it is *one* process integrating both systems as one new coupled system.[8]

As more complex examples of dynamical couplings reveal, not only the *amplitude* of a joint vibration can be affected by resonance, but the vibration's *phase* and *frequency* as well. This is the point where the more powerful mathematical framework of dynamical systems theory is brought into play. In the 17th century, Huygens observed that two pendulum clocks on a wall synchronize in their oscillations after a certain time through a minute exchange of forces through the wall.[9] As another example, the three Jupiter moons Ganymede, Europa, and Io are in a coupled state of what in celestial mechanics is referred to as "orbit-orbit resonance" (Murray and Dermott 1999, 9). Considered independently, each of the moons could be described as a simple dynamical system revolving around Jupiter at a frequency determined (using Newton's law of universal gravitation; see Tipler 1999, Ch. 11) by three parameters: its orbital distance from the center, its own mass, and the mass of Jupiter. However, as it turns out in observation, their actual frequencies of revolution deviate from these individually calculated values. In fact, they turn out to be in an exact mutual ratio of 1:2:4 (i.e., Io revolving 4 times, Europa 2 times faster than Ganymede) and they are in a certain state of phase locking (see Murray and Dermott 1999, 10–11, 396–399). This is hard to account for in the descriptive perspective of three independent systems. However, the three systems are not separate but coupled through mutual gravitation, and only a theoretical model of the three moons as *one* coupled dynamical system can predict the mutual ratio of rotation frequencies of 1:2:4 as well as the phase locking in accordance with empirical measurement.

This mechanical phenomenon is called "orbit–orbit resonance" as the rotation of each of the moons is *affecting and being-affected-by* the rotations of the other moons (by means of mutual gravitational forces). In this *entanglement of moving and being-moved in relation,* the moons get *attuned* or *coordinated* with each other in frequency and phase. Moreover, the frequency ratio of 1:2:4 is an integer relation, featuring "a high degree of symmetry" as physicists say, which refers to the fact that after each four

[8] Most physics textbooks approach the notion of resonance starting from "forced oscillations". This is the extreme case where the excitating system A ("external force") is not back-influenced by the coupled system B, neither regarding its amplitude nor its frequency (see French 1971; Morse 1948; Tipler 1999). These presentations neglect the feedback of energy from B to A, which is a typical physical idealization in the sense of a "limit case". At the same time, this didactic practice introduces a conceptual asymmetry, disowning the bi-directional feedback effect described above, which becomes relevant as soon as the power supply of A is of comparable order to B. See Morse 1948, 52, who is one of the few to mention this drawback and make a transition to symmetrical interactions in the chapter on "Coupled Oscillations").

Also, I do not follow here the strong terminological distinction made by Rosenblum and Pikovsky (2003) between "resonance" as the asymmetrical case of one passive and one active system, and "synchronization" as the case of two coupled oscillatory systems on equal footing. I will generally refrain from using the word "synchronization" as it does not highlight the joint co-constitution of the relational dynamic but rather seems to come with an implicit understanding of two pre-constituted entities, meeting in their individual behavior at some kind of a compromise or middle point.

[9] See Pikovsky et al. 2001, 2–3. Note that much of the literature treats this phenomenon of resonative attunement as an example of mere phase (anti-)synchronization. But if the idealizing presumption of equal frequencies of the two clocks is dropped and very close but non-equal individual frequencies are assumed, there is also a mutual attunement of the frequencies. That is, the one pendulum swings a bit faster, the other a bit slower compared to the cases of isolated oscillations of each pendulum.

turns of Io, the system of the three moons is again in the same configuration of mutual positions.[10] As it turns out, the solar system is full of such highly symmetrical rotational resonance couplings, and this is what makes it dynamically *stable.* Through orbital resonance, the various rotational objects *jointly establish* a dynamic in which each of them behaves slightly differently from the case without interactive coupling ('individualistic case'). But in turn, *this dynamic being-in-relation, as a whole,* is mutually stabilizing in the sense that it may resist smaller a-periodic perturbations (such as asteroids and comets).

These examples illustrate how in classical physics, resonance is used to describe a joint dynamic of various sub-components that is only apparent as a whole. But what is more, in resonance, these subcomponents are *held together* in an interplay of moving and being-moved in relation, of dynamically constituted mutual *forces.* These forces are highly selective to the concrete relational setting and unite the single objects or systems in a joint movement. As an effect of this dynamic, a new quality of relational stability is constituted, such as the mentioned amplification of vibrations (guitar string, shower cabin) or the resilience to perturbations (Jupiter moons, solar system). This emphasis on the dynamic interplay of *immanent forces* in resonance suggests that resonance is more than a correlation of temporal patterns of individual state functions, to which the notions of coordination, synchrony, and attunement boil down. Resonance is a processual unfolding in a joint movement, whose path is dynamically *created* in the entanglement of moving and being-moved. This *creative* or *constitutive* aspect of resonance is not conceded its full ontological weight in an external descriptive framework based on state functions, where the dynamic forces are ontologically derived (i.e., mathematically given by the second derivative).

2.4 Conceptualizing resonance in social interaction

In this section I will adopt resonance as a philosophical concept to describe relational qualities in social interaction. Importantly, however, this should not be confused with a naturalistic approach describing social interaction *as* physical systems in resonance. Rather, our task is to *transpose* the notion of resonance into the realm of sociality in a way retaining its central qualitative aspects while not committing to the ontology of a physical model comprised of "systems" and "states". Referring to concepts from Henri Bergson and Gilles Deleuze, I will formulate the concept of affective resonance in a primary ontology of relational forces, potentials and processual unfolding.

To start with an example, it is often observed that gestures and facial expressions, or the way of laughing with one another, mutually attune during a conversation. In a similar way this holds for dynamic aspects of spoken language, such as rhythm, intonation and accent. In these cases, the interactants' interplay shows a dynamic unfolding which is highly particular to the concrete relation and situation. To get a theoretical grip on these phenomena, I suggest adopting the concept of resonance. Similar to the example of the three Jupiter moons mentioned above, this will allow us to

[10] If the frequency ratio is not integer, it is possible that there is no repetition in the configuration of mutual positions of the three moons ever. The phase locking is another aspect of dynamic stability, which cannot be described in more detail here, but see Murray and Dermott 1999, 396–399.

see the attunement as a relational dynamic which is irreducible to individual action because it deviates in its joint unfolding from any individually preconceivable path.

However, as soon as we are talking about *social* interaction which is experienced from an immanent perspective by the social agent, it is neither adequate nor possible anymore to locate the relational behavior and the joint affective experience on a quantitative scale as it was done with the rotation frequencies of the Jupiter moons. The joint way of laughing or talking with one another is not—in whatever sense—a midpoint halfway between individual behaviors, neither is it an "average" or a "linear combination" of such. Conceiving the joint behavior in terms of deviation would actually imply the construction of fictitious individual behaviors of the interactants and a metric space around to measure the deviation. This would lead to a quantifying external perspective, stripping resonance down to a mere correlation. Phenomenologically, however, it seems adequate to see the resonative affective engagement in its entirety as something qualitatively new and self-contained, and in its concrete form as highly sensitive and specific to the relation. In this sense I will henceforth say that affective resonance *constitutes* a quality of being-in-relation.

From the individual perspective, affective resonance is experienced as a simultaneity of moving the other(s) and being moved by the other(s), a movement-in-relation which is only partly under my control. This can best be seen in the example of the exuberant dance party mentioned in the introduction. In the unfolding dynamic of being immersed in a dancing crowd, I am contributing to the group dynamic and, *at the same time,* I am gripped by it. The dynamic acts on me, it makes me move—not in an externally determined way, but in my own way—, and thereby it gets enacted by me, I carry it further. The resulting joint movement is not accountable as a composition of individualized voluntary action, aiming at a certain preconceived target state. Phenomenologically, the joint movement is much rather an unfolding of *forces* that are inherent to the relational and situational configuration. The experience of being-in-resonance is constituted by an immediate experience of these forces, taking hold of oneself within the joint dynamic.

These observations can only be accommodated in a conceptual model which takes an *ontology of differential forces* as primary rather than being founded on an ontology of system states. This has two reasons. (1) Resonance is immediately experienced by its dynamical qualities, but accounting for its processual unfolding as a succession of states such as given by a state function would leave the actual dynamical qualities as something derived. Movement would be reduced to the interval or the transition from a current state to future states; the higher order dynamics are respectively given by higher order *derivatives*. The immediate experience of being-in-resonance, however, is that of a present force, taking hold of oneself in a joint dynamic of moving and being-moved. This calls for an understanding of processuality as brought about, in each moment, by relational forces that precede, ontologically, the actual range of states the movement and the affective experience will be running through.

(2) Thus, modeling the dynamical qualities of a process as derived from an ontology of states would assume that the range of *possible* states is *conceivable prior* to the movement. The unfolding of the process would be limited to a path within this space of predetermined possibilities, which is for instance given by a coordinate space, containing all the hypothetical system states as possibilities. An ontological understanding of the dynamic forces of resonance, in contrast, would enable us to conceptualize the

constitutive aspect of resonance. It would make visible that resonance is a process in which the space of immanently and immediately conceivable possibilities itself gets continuously reshaped and reformulated—in a way that goes beyond the universalizing abstraction of state coordinates.

In this description I have distinguished the notion of *movement within* a preformed range of possible system states from the notion of *processual constitution* of possibilities. In this, I am relying on the distinction between *the possible* and *the virtual* as a theoretical figure known from Henri Bergson and Gilles Deleuze (cf. Deleuze 1991, in particular 96–98; 1994). Bergson used the concept of "the virtual" when he was puzzled by the question of biological evolution as a process continuously producing new forms which are not preconceivable as possibilities from the current stage within the process (see Bergson 1907). Thus he is facing a problem which is quite similar to ours. Turning to an immanent perspective on the unfolding of evolution, Bergson refuses to think of processual unfolding in a static ontology of states. Instead he characterizes evolution as an "elan vitál", as "the force of time as production of novelty" (see Guerlac 2006, 189). He calls this force *virtual,* as it precedes the *actual forms* it may bring about.

In Deleuze's reading of Bergson, this notion of the virtual undergoes an abstract theorization as an ontological register of pure forces or "differential elements", built into his immanent philosophy of "self-differentiation" (see Deleuze 1991, 94–103; 1994, 208–214. Cf. also Guerlac 2006, 176–196; Badiou 1999, 43–53; Protevi 2013, 137–152). The possible and the virtual are conceptual opposites in that they are connected to different notions of processuality. A possibility undergoes the process of a "realization", which Deleuze calls a "brute eruption" or a "leap" from non-existence to existence (Deleuze 1994, 211), because a possibility is something which is logically already there, "it only lacks existence" (Badiou 1999, 48). The realization of a possibility is a process completely governed by the "rules" of "resemblance" and "limitation", it *limits* the arising real thing to resemble that which is logically preconceivable as a possibility. However, as preconception always models after what has already been real, nothing new can arise through realization of possibilities (see Deleuze 1991, 98).

The virtual, on the other hand, undergoes a process of "actualization", which reminds of a 'force's performing work' in physics. Instead of instantiating resemblance to a possibility, the process of actualization *creates* its own path of action and is *productive* in its unfolding. "[I]n order to be actualized, the virtual cannot proceed by elimination or limitation, but must *create* its own lines of actualization in positive acts." (97) Unlike a possibility, a virtuality does not contain, in its essence, a reference to a target point of its process of actualization. "While the real is in the image and likeness of the possible that it realizes, the actual, on the other hand does *not* resemble the virtuality that it embodies." (97) Thus, conceiving the dynamic forces of resonance as virtual implies locating them in an ontological register which is not derived from the register of actual forms or states.

2.5 Affective resonance and affective-relational individuation

The virtual understanding of the dynamic forces of resonance leads to a differential—as opposed to teleological—understanding of the interaction process, because it treats the forces as substantially distinct from the "novel form" the process creates as actualization of the forces. Now, processes of resonance in social interaction have the additional

characteristic that the dynamic forces are *arising within the relation* from an entanglement of moving and being-moved. That is, not only in the absence of a defining target point, but also in their virtual origin do the dynamic forces of resonance escape the paradigm of voluntary individual action. Because being-in-resonance is an actualization of forces that are inscribed in the relational space, it is experienced as being gripped in a *joint* dynamic. It is in this sense that being-in-resonance constitutes an immediate experience of relatedness, while the perception of individuality and individual action is secondary and derived.

Yet I do not disavow that specific characteristics of the involved individuals are shaping the resonance dynamic. With respect to our elementary social examples—talking, laughing, and dancing with one another—it is clear that not every two individuals would resonate together in the same way. Generally, the concrete form of resonance would immediately change if one of the individuals got replaced with another one in the same situation. To conceptualize this individual *specificity* and *sensitivity* of resonance, I suggest attributing a *potential to resonate* to each of the individuals. Here I understand the Aristotelian notion of a potential as an individuation of the dynamic forces of resonance, but as an individuation that remains essentially tied to relatedness. That is, the potential to resonate *can only be actualized in relation.* The individual potential to resonate belongs to the register of the virtual, but it needs to be selectively activated in a concrete relation and only then can it unleash in a *joint* dynamic.[11] This activation in relation is not additive, but a process of mutual modulation and interference. The other(s) make(s) me move and I move the other(s), but in selective and mutually modulating ways.

If the individual was only ever in one single relation, one could rightly object that the notion of the "individual potential to resonate" is a mere construct—as it never directly reveals itself in force or action. But relatedness is plural, especially in the diachronic dimension, and every past experience of being-in-relation and being-in-resonance shapes and forms the present and future individual potential to resonate, the specific 'frequencies' on which one can be moved. Hence, *the individual history of being-in-resonance gets sedimented, thus constituting what may be called affective-relational individuality (or 'affective subjectivity').* This affective subjectivity—in the sense of a sedimented history of being-in-relation—modulates the resonance dynamics of future relations. In this precise way does a theory of affective resonance come with an *ontogenetic* understanding of the individual. The individual gets constituted processually, as a node in a network of affective relatedness, and at the same time does the individual enact itself through relational actualizations of its potential to resonate. The concrete forces of a resonance dynamic are thus not only in a synchronic sense inherent to the relation, they are as well diachronically shaped, as a product of the past of the resonance process itself, thus co-shaping its future unfolding.

[11] The notion of potentiality goes back to Aristotle. However, the specific way the concept is used in the present context departs from its Aristotelian origins in two respects. First, as Protevi (2013, 143) points out, "[f]or Aristotle, potentials are always oriented toward their telos in actuality." Considering potentiality as a kind of virtuality, in contrast, implies a non-teleological understanding of its process of actualization. This twist goes back to Deleuze, cf. 1994, 182–185, 208–212. Second, I am proposing a specific *relational* reading of the concept of potentiality. This relates to the ontological and relational understanding of power in Baruch Spinoza, especially in its constitutive form as *"potentia"*. See Saar 2013, 133–167.

One of the benefits of the concept of affective resonance is that it offers an alternative to the notions of mimicry (or mimesis) and imitation, which are used in psychological theories of "emotional contagion" (see Hatfield, et al. 1994) and have recently been taken up in affect theory (see Gibbs 2010). In these contexts, mimesis and imitation rely on notions of resemblance and similarity, comparing behaviors or "affect states" (193) of separate individuals from an external perspective. There is a whole spectrum of specific conceptions of mimesis ranging from a "transmission", "contagion", or "sharing" of "affect states" or behavioral patterns between individuals[12] on the one end, to an inner capacity to bring about similarity in behavior on the other end. But all these understandings have in common that they describe separate, individually owned behaviors or "affect states", and not an affective quality or a behavior which is jointly *created* and dynamically stabilizing in interaction. *Resonance, in fact, is less about similarity in behavior than about co-constitution of (potentially even divergent) behavior within a joint dynamic interplay.*[13]

Moreover, I shall mention that the concept of affective resonance is not limited to cases of synchronizing and attuning behavior or experience. Sometimes, or in some aspects of the behavior, there may just be *no* resonance, or even *dissonance*—a feeling of repulsion which may make the interactants behave in an oppositional manner rather than attune to each other. But such a dissonant dynamic is yet a moving and being-moved in relation, an unfolding of relationally constituted forces. Thus it falls under the general notion of resonance. A resonance dynamic can as much be antagonistic and separating as it may be 'connecting', yet it will be a joint movement that is qualitatively distinct from individual behavior.

2.6 "Affect attunement" (Daniel Stern) vs. affective resonance

Daniel Stern's description of relational processual qualities in the infant-caretaker dyad can be seen as paradigmatic for affective resonance. Under the name of "affect attunement" Stern refers to an observed coordination in rhythm, timing and "activation contours" of vocal utterances, facial and bodily movements. This coordination occurs spontaneously but most of the time in the mutual presence of infant and caretaker (see Stern 1985, 47–61, 138–161). It happens involuntarily and subconsciously—even an adult is not necessarily aware of it—, and beyond propositional exchange, signification, and meaning. At age of 9–15 months, it is the primary form of relating to other persons, and it remains a fundamental capacity of social interaction also after the acquisition of language and in adulthood.

Affect attunement is an essentially dynamical quality, established in joint temporal patterns, contours and rhythm. At the same time, it is irreducibly relational, in the sense

[12] "At the heart of mimesis is affect contagion, the bioneurological means by which particular affects are transmitted from body to body." Gibbs 2010, 191.

[13] It will be elaborated in upcoming work that applying the concept of affective resonance to social phenomena which have long been established as examples of mimesis may facilitate a collective and socially situated instead of individualized and naturalized understanding of their genealogy. Examples such as "epidemics of hysteria or multiple personality disorder", "each of which can be seen, at least in part, as contagious mimetic phenomena" (Gibbs 2010, 190) give an idea of the political relevance this pursuit may have.

that it is bound to a bi-directional real-time coupling in the dyad, as the famous double-TV experiments by Murray and Trevarthen (1985) have shown.[14] As a consequence of both, affect attunement establishes a relational-processual entanglement of the interactants which gives rise—in Daniel Stern's words—to an immediate "experience of feeling-connectedness" (see 156–157).

It is the description of an affective quality that lies in a temporal dynamic of interaction that makes for the revolutionary aspect of Daniel Stern's approach and gives rise to the ongoing reception of his writings in present branches of affect theory (see for instance, Hansen 2004; Leys 2012; Massumi 2002; Angerer 2007; Papoulias and Callard 2010). Systematically, the import of Stern's work to affect theory challenges categorical understandings of affectivity which have lately been revived under the influence of neuroscience. These broadly Darwinian views see in affects and emotions a discrete set of innate and 'hard-wired' stimulus–response circuits located in the brain ('basic affects' such as fear, anger, joy, sadness, …) which are taken to be phylogenetically old and brought about by evolutionary selection (see Damásio 2003; Leys 2012; Sedgwick and Frank 2003; Tomkins 1962–1992). In contrast to this, Daniel Stern's dynamical approach suggest a view of affectivity as a dynamical quality within social interaction.

To shift from exposition to the mode of a critique, the phenomenon of affect attunement is clearly an example of resonance as formulated above. But yet it is to be noted that Stern's (1985) own theorization of this phenomenon remains bound to a paradigm of methodological individualism and individual mental states. He does not oppose categorical affect theories on terms of their inherent inner/outer logic (affects as circuits *within* the brain, responding to *outer* stimuli), but he refines them on temporal terms. He sticks with the notion of "internal feeling states" (151) but extends the discrete range of categorical affects by adding to them a new and dynamical kind he terms "vitality affects" (see 53–61, 156–157). Under this name he constructs precisely a mental state foundation of what outwardly manifests as temporal patterns and contours comprising the relational phenomenon of affect attunement. Vitality affects are "one of the kinds of subjective inner states that can be referenced in acts of attunement" (157). "Tracking and attuning with vitality affects permit one human to 'be with' another in the sense of sharing likely inner experiences on an almost continuous basis." (157)[15]

This shows that although it is the primarily observed phenomenon, Stern makes affect attunement a derived capacity in his theorization, a capacity of sharing pre-existent feeling states between pre-existent individuals. Out of this situation I suggest using the notion of resonance as formulated above to conceptualize the phenomenon of affect attunement as *affective resonance.* This would allow to see the affective quality not as "shared" or "transferred", but as *jointly created* in the process of resonative

[14] Murray and Trevarthen (1985) showed that infants can affectively attune with a caregiver who is presented to the child from another room through a realtime double TV-camera setup. But they get "distressed" if instead of the live image of the caregiver a recorded sequence from earlier in the same interaction is presented. This indicates that affect attunement is a processual and irreducibly relational quality of interaction. It cannot be broken down into separate processes within the single individuals, and neither to mimesis or imitation. See also Trevarthen 1998 and Tronick 1989. For an overview see Beebe et al. 2003.

[15] As Philip Cushman (1991) pointed out, Stern's theory can be analyzed as covertly reaffirming a culturally and politically dependent anthropological conception of the human and the self in Western thinking. As he points out (see, e.g., 210), this conception is an implicit background assumption or epistemic stance underlying Stern's theoretical model, rather than a consequence of his observations (hermeneutic circularity).

interaction itself. Affect attunement could then be theorized as a productive force within a field of *affective relationality,* from which the feeling individual with its "shareable inner universe" of "feeling states" arises as a *product.* In fact, this resonative reading of Daniel Stern would turn the relation of "inner feeling states" and attunement upside down. It would lead to an *ontogenetic* understanding of the subject in a relational and processual sense. In a process of 'affective subjectivation', subjectivity and the experience of individually owned feeling states arises from the life-long history of being-in-relation by means of affective resonance.

3 Conclusion: affective resonance and immanent emergence

The proposed concept of affective resonance could become a new paradigm in thinking about social interaction. It makes visible that a great share of affective experience and social behavior is in fact *constituted* within a relational dynamic of being moved and simultaneously moving the other(s). Approaches in interactive social cognition strive to describe this phenomenon using concepts from dynamical systems theory, but I argued that their implicit naturalistic framework is detrimental to the phenomenal accuracy of the account. Making a shift towards an immanent perspective upon the *experience* of being-in-resonance, I developed an ontological and creative conception of affective resonance, based on the following three main axioms:

(1) Affective resonance is a dynamical entanglement of moving and being-moved in relation, of affecting and being-affected, which is *sensitive* and *specific* to the concrete relational and situational configuration.
(2) Affective resonance is primarily experienced as a gripping *force*, which is immanently arising in the relational interplay and actualizes in a jointly unfolding dynamic.
(3) Affective resonance is a *creative* dynamic, it produces its own lines of a movement-in-relation. This constitutive aspect of resonance is conceptualized giving ontological primacy to the dynamic forces arising within the relational configuration instead of assuming a pre-formed range of states the movement could be running through.

As I have argued, affective resonance is distinct from imitation, synchrony and mimesis because it does not amount to an *identity* or *resemblance* of behavior and affective experience. Essential to affective resonance is less the *outer* congruence in form but rather the *immanent connectedness* within a dynamic of forces that are arising in relation (see the example of the three Jupiter moons in section 2.3). The outcome of such a dynamic is not necessarily identical or synchronic behavior, but movements and affective sensations which are bi-directionally co-constituted and co-shaped in the relational interplay.

With respect to interactive social cognition, the paradigm of affective resonance challenges the conception of social interaction as coordination, and the conception of coordination as correlation. For such a framework relies on an implicit ontology of "systems" and "states", described by state spaces, state functions and differential equations. Modeling the state space means *preconceiving* the range of dynamic

possibilities; solving an evolution equation amounts to solving it *with respect to this preconceived state space.*[16] In the proposed ontological understanding of relational dynamic forces, in contrast, joint *becoming* precedes the static logic of *being* in coordination. The dynamical qualities (higher order derivatives) are taken as more fundamental than states, which reduce temporal progression to what can be seen in a snap-shot photo.

I pointed out that the shift towards an immanent perspective on being-in-resonance also prompts us to suspend the epistemological hierarchization of fundamental physics versus emerging higher-level structures of sociality. Sociality cannot be understood as a macro structure, qualitatively distinct from the interactive microdynamics of independently existing physical agents and microprocesses. Instead, the proposed conception of affective resonance augments the *ontogenetic* empirical approaches in developmental psychology towards an *ontogenetic conceptualization of the individual.* Following this understanding, the individual is always already in social interaction and in constitutive becoming (synchronic and diachronic relatedness). Concretely, the newborn is born into an already social world, and from the outset s/he is relating as much socially as physically by means of affective resonance.

As a consequence, we have to think emergence not along a hierarchy of scales and as proceeding from fundamental physics to macroscopic sociality, but as *diachronic and immanent emergence.* It is not sociality that emerges as a whole, but relational qualities that emerge locally and *within* social interaction. Emergence in this sense goes back to the constitutive aspect of resonance: Affective resonance happens as a process which creates its own lines of unfolding. In the irreducible dynamical entanglement of moving and being-moved, affecting and being-affected, it creates movements and affective experiences which are specific to the situation and relation. This process does not lead outside the immanent realm of experience, it is the *immanently productive work of relational forces, giving rise to a quality of relatedness.*

In future work, I will extend these lines of thought towards a theory of *affective individuation* or *subjectivation* within a field of *primary affective relationality.* That is, I will explain in more detail how in the life-long processuality of being-in-relation by means of affective resonance, a kind of subjectivity—in the sense of the *individual potential to resonate* which is given by the *sedimented history of being-in-relation*—emerges diachronically and immanently. Subsequently, this conception will enable a relational-processual approach to *social structures*—from elementary cultural similarities in facial expressions and gestures to complex power regimes such as contingent gender roles. Being inscribed in the individual potential to resonate, social structures are enacted and embodied by the individuals through actualization in affective resonance. In this way, social structures are never perpetuated *identically,* but in a *differentiating* way within each single relation. This, finally, makes affective resonance useful as a paradigm to investigate how situational social microdynamics may lead to certain kinds of social transformation.

[16] This refers to the mathematical fact that the solution of a differential equation depends crucially on the assumed state manifold.

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