Chapter 17
Forms and Functions of Affective Synchrony

Adrienne Wood, Jennie Lipson, Olivia Zhao, and Paula Niedenthal

Abstract The reproduction of another individual's emotions in the self—the embodiment of perceived emotions—has been demonstrated to constitute one mechanism for emotional information processing. That is, seeing someone's emotional expressions and using one's own face to make the same expression helps the perceiver represent the emotion of the other. When members of a dyad mimic each other's emotional expressions and by consequence converge in their underlying physiology over time, we say that the dyad has reached a state of affective synchrony. The present chapter brings together recent theorizing and research on physiological and expressive affective synchrony. We propose that affective synchrony serves three interrelated functions: it enables efficient information exchange, allows for interpersonal emotion regulation, and builds social bonds. We review evidence for the contexts in which affective synchrony arises, propose, and evaluate the benefits and costs of achieving these states, and end by suggesting paths for future research in this area.

Keywords Embodiment · Mimicry · Emotion · Synchrony · Physiology

Most of social life boils down to moments of connection. People are usually in the business of getting together, staying together, and pursuing behavioral goals together. They flirt, dance, build, converse, play, and even paddle in double kayaks and ride tandem bicycles. Successful connection is not simple, however. At a basic level, acts of connection involve precise temporal and spatial coordination. Furthermore, people are not social agents that can be programmed to coordinate. During the interaction, real people have emotional responses that sometimes motivate them (e.g., telling them that they do or do not want to continue with action) and serve to regulate their specific behaviors (e.g., telling them whether to approach or avoid something or someone). Thus, in moments of social connection, two or more people monitor,

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predict, and regulate each other's emotions (e.g., Michael, 2011). How do people accomplish this? How do shared emotions serve to help people get together, stay together, and pursue common goals?

As is the case for the emergence of coordinated motor behavior—joint action (Knoblich et al., 2011)—one mechanism for coordinated emotions is an embodied one. As people monitor each other's emotions, they tend to produce elements of the perceived emotion in themselves. For example, people make the same dynamic facial expressions as those they observe. The act of mimicry, in turn, contributes to a cascading activation of the neural states involved in experiencing other components of the emotion (Wood et al., 2016). When two people's emotions align in form as well as temporal dynamics, we can say that a dyad has come into affective synchrony.

The present chapter is about how and why the components of individuals' emotions become synchronous. We will focus our discussion on the synchrony that can emerge within a dyad, although groups of any size can synchronize, and we occasionally point to relevant findings about group synchrony. We define synchrony as the dynamic and reciprocal adaptation of the timing of corresponding emotional components of members of interacting dyads. The synchronous state may conform to the mathematical description of an oscillator, with a periodic, repeating rhythm, or it may take a different shape. In this chapter, we thus call the state of two people's emotions coming into embodied temporal and spatial alignment *affective synchrony*. Behavioral affective synchrony as we define it is somewhat distinct from behavioral *mimicry* (Lakin & Chartrand, 2003), which tends to refer to the alignment of emergent categories of behavior (e.g., smiling and head-scratching) rather than continuous measures. Furthermore, we do not say that people "mimic" each other's physiological states, so we use the term "synchrony" throughout this chapter to unite the discussion of behavioral and physiological variables.

We first review evidence for *physiological* affective synchrony with a focus on three types of dyads: caretaker–child, romantic partners, and client–therapists. We then make several novel theoretical contributions to the affective synchrony literature. We point out that affective states are not directly transmitted from one person to another—like all forms of information, they require a communication medium. That medium is observable behavior, such as facial expressions, pupillary dilation, and speech. We, therefore, suggest that observable behavioral cues drive physiological synchrony, particularly when those cues become synchronized across people, which we refer to as *expressive* affective synchrony. We next integrate evidence in favor of several functions of affective synchrony. These include the proposals that affective synchrony provides (1) a common basis for information processing, (2) an efficient means for finding and meeting challenges and opportunities in the environment, and (3) stronger social connectedness through the generation of feelings of similarity and closeness. We note that affective synchrony sometimes fails to serve these positive functions and can have negative consequences for social interactions and relationships depending upon the emotional context, type of social interaction, and individual characteristics. The negative consequences include the maintenance or escalation of both interpersonal conflict and maladaptive affective responding. We end by suggesting where affective synchrony research might most productively go next.

Physiological Synchrony

Coordinated social interaction involves layers of shared and synchronized physiological processes at multiple timescales (Bietti & Sutton, 2015; Yun et al., 2012). Conversation partners synchronize their pupillary dilation, suggesting the partners' moment-by-moment changes in attention and arousal are linked (Kang & Wheatley, 2017). Partners display synchrony in autonomic nervous state measures, such as heart rate (Mitkidis et al., 2015), breathing (Ferrer & Helm, 2013), skin conductance (Mønster et al., 2016), and cardiac pre-ejection period (West et al., 2017). More global interpersonal neural synchrony occurs during the conversation, in terms of both the timing and content of brain activity, reflecting shared understanding (e.g., Stephens et al., 2010). Some social species even synchronize their daily sleep–wake rhythm (Favreau et al., 2009), suggesting physiological synchrony between bonded individuals can extend even to these slower timescales.

Due to its important roles in promoting bonding and emotion regulation (see "Functions of affective synchrony"), many investigations of physiological affective synchrony examine the synchronization of physiological reactivity in mothers and infants. But classic work investigated physiological synchrony in adults, including between clients and their therapists and romantic couples, as well. In this section, we focus on research that specifically examines synchronization of autonomic nervous system (ANS) processes such as heart rate, electrodermal activity, respiration, and heart rate variability (HRV; for a review of physiological synchrony, see Palumbo et al., 2017). These autonomic signals react to alterations in emotional states and covary in different ways, including conforming to oscillating patterns.

Caretaker–Child Synchrony

Research on mother–infant synchrony was itself inspired by demonstrations that mammalian mothers, through the mechanism of social contact, align their physiological systems with those of their young in order to positively affect the infant's growth (Schanberg et al., 2003) and modulate brain structures implicated in the regulation of stress (Champagne, 2008) and cardiovascular rhythms (Hofer, 1971).

Similarly, human caretakers and infants have been shown to synchronize their cardiac rhythms through the mechanism of touch (Waters et al., 2017) and also through visual and auditory cues (Feldman, 2007). In a study by Feldman and colleagues (Feldman et al., 2011), cardiac measures of mothers and their 3-month old infants were taken while they engaged in face-to-face interactions, and mothers and infants were also videotaped. Time-series analysis applied to the cardiac output revealed that that mother and infant heart rhythms, but not those of pseudo-dyads, became synchronized with time lags of less than 1 s. Experimenters also coded gaze, expressed affect, and vocal behavior for evidence of synchrony. Analyses relating physiology to these interpersonal behaviors showed that synchrony in maternal and infant heart rhythms increased during periods of affective and vocal covariation, suggesting the emergence of a broader biobehavioral alignment (Atzil et al., 2012).

Water et al. (2014) observed synchronous heart rate in mothers and infants after mothers had experienced a laboratory stressor. The researchers brought mother and infant pairs into the laboratory and temporarily separated the pairs. During the separation, mothers were randomly assigned to a modified Trier Social Stress test in which they received a positive evaluation or negative evaluation during the delivery of a speech and a question and answer period. Mothers in a control condition performed the speech task while alone and received no evaluation. Physiology of mothers was recorded during the task and physiology was recorded in both mother and infant during a reunion period. Results showed that infants' physiological reactivity covaried with mothers' physiological reactivity. Furthermore, the negative-evaluation condition generated higher synchrony in mothers and infants, and this increased over time. Some evidence of synchrony in facilitating social learning was indicated by the finding that the infants of mothers who had been assigned to the two social evaluation conditions later showed more avoidance of strangers in the laboratory (i.e., people who might have stressed the mothers) than infants whose mothers were in the control condition.

Caretaker–child physiological synchrony is observed beyond infancy as well (Main et al., 2016). Woltering et al. (2015) studied the relationship between physiological synchrony and dyadic attunement (or interpersonal responsiveness) in mother–child interactions. Mothers and their 7- to 12-year-old children were invited into the lab to have discussions of both positive and more conflictual topics while being videotaped. Dyadic attunement was manually coded as a sum of signs of engagement, joint attention, and reciprocity. The heart rate of both members of the dyad was measured and physiological synchrony was estimated using a Structural Heteroscedastic Measurement-Error model, which detects linear relationships between two discrete time series. Higher dyadic attunement was observed in positive discussions (i.e., what would you do if you won the lottery) than in a conflictual discussion (i.e., topics of persisting disagreement). Dyadic attunement, at least in smoothly functioning dyads, thus seems to arise more in interactions characterized by positive emotions. Moreover, dyadic attunement predicted higher physiological synchrony. This was particularly true during a positive interaction that followed the conflictual one, which suggested to the authors that synchrony positively predicts relationship repair.

Romantic Partner Synchrony

Physiological synchrony continues over development and has long been documented in romantic couples. In a series of classic studies, for example, Levenson and Gottman (1983) examined sympathetic nervous system (SNS) synchrony between married couples during social interaction tasks. In one, involving a conversation about a negative topic, couples who had identified themselves as high in marital distress showed higher synchrony in heart rate, skin conductance, pulse transmission time, and somatic movement than did non-distressed couples (Levenson & Gottman, 1983).

Neither group showed physiological synchrony during a conversation about events of their day. The authors concluded that couples in distress reciprocate negative affect at the physiological level, whereas non-distressed couples do not. However, significantly more research on synchrony during couples' interactions has been conducted since, which taken together suggests a more complex view of the presence and function of physiological synchrony in married and romantic partners, as discussed further below (Liu et al., 2013; Palumbo et al., 2017; Papp et al., 2013; Saxbe & Repetti, 2010; Timmons et al., 2016).

For instance, Helm et al. (2012) examined the covariation of respiration and heart rate during tasks in which couples gazed into each other's eyes and in which they attempted to mirror each other's physiology. They modeled the physiological signals using coupled linear oscillator models (e.g., Boker & Nesselroade, 2002). The couple's respiration was found to synchronize during the gaze task and, to some degree, during the imitation task. For heart rate, the findings showed synchrony between couples across both tasks. Similar levels of synchrony were not observed in the patterns of pseudo-dyads that were randomly constructed for comparison, suggesting that only couple's heart rate and respiration are shared during interactions designed to elicit shared emotional arousal. Rather than relating to entrenched conflict, synchrony in these more neutral and positive interactions seems to be associated, as with infants, with dyadic attunement—that is, with a positive connection.

Client–Therapist Synchrony

A similar set of demonstrations have been reported regarding the physiology of clients and therapists during psychotherapy, which is a context in which empathic responding is particularly important (Karvonen et al., 2016; Pascual-Leone, 2009; Ramseyer & Tschacher, 2006, 2011). For instance, Marci et al. (2007) measured skin conductance in psychotherapy clients and their therapists during live clinical encounters. They found that skin conductance alignment during psychotherapy sessions predicted clients' ratings of therapist empathy. Additionally, observer ratings of clips from the sessions indicated that clients and therapists displayed more solidarity and positive regard during moments when their skin conductance concordance was higher.

In a more recent study, Tschacher and Meier (2019) observed significant synchrony between clients and therapists, compared with pseudo-dyads, on multiple physiological indicators including respiration, heart rate, and heart rate variability. Synchrony was assessed by both cross-correlation and concordance (correlation of local slopes) methods, and the level of synchrony positively predicted client reports of the therapeutic alliance.

Expressive Affective Synchrony

How does a dyad achieve the embodied state of physiological affective synchrony, when much of the body's physiological state is not outwardly observable? Some instances of physiological synchrony occur because two members of a dyad are attending to the same external event; e.g., two friends watching a scary movie together will have highly synchronous SNS activity simply because they are responding to the same stimulus. Such parallel affective experiences can still increase feelings of social closeness and liking (Cheong et al., under review). However, this form of synchrony does not require that partners be able to see, feel, or hear each other, and does not involve mutual causal influence between partners' affective states.

In instances where partners are influenced by each other's physiological states—and not a third variable in the environment—the partners must somehow transmit information about their physiological oscillations (Repp & Su, 2013). In other words, they must produce observable cues that their partners embody, and such behavioral synchrony then facilitates physiological synchrony (e.g., Oullier et al., 2008). The observable cues may be tactile (Chatel-Goldman et al., 2014; Waters et al., 2017), visual (Schmidt & O'Brien, 1997; Schmidt et al., 1990), or auditory (Eckland et al., 2019), the latter being particularly powerful synchrony attractors (Repp & Penel, 2004). The more partners attend to each other's expressive cues, the more likely they are to synchronize with them (Richardson et al., 2007), highlighting the mediating role of communication. Partners may even achieve mutual eye contact in order to increase their partner's attention to their communicative signals and thereby increase interpersonal synchrony (Leong et al., 2017).

Communication takes two forms: signals and signs (Bradbury & Vehrencamp, 2011). Signals are communicative behaviors whose primary function is to transmit information between individuals. A soothing spoken utterance intended to calm a restless baby and a scream that alerts group members about danger are two examples of communicative signals. Communicative signals have predictable effects on a perceiver's physiology, as demonstrated by Martin et al. (2018) in a study of the effects of different types of smiles on heart rate and cortisol production. People can also influence the physiology of their interaction partners by producing affect-modulating signs—behaviors that incidentally convey information about the producer's affective state. For instance, shaky hands might be a sign (rather than a signal) of anxiety that can mediate the transfer of arousal from one person to another. Some behavioral cues do not fit neatly on one side of the sign-signal dichotomy; e.g., is tearful crying a communicative signal or a sign-like byproduct of physiological dysregulation? But for our purposes, the relevant point is that physiological affective synchrony in a dyad is mediated by the continuous exchange of perceptible signs and/or signals about the partners' internal states.

How much communication is required to maintain affective synchrony in a dyad? Dyads can be more or less similar in their affective and physiological responses to events, perhaps due to personality differences. Vallacher et al. (2005) argue that such similarity will determine how much communication and interpersonal influence the dyad needs to maintain physiological synchrony. Dissimilar dyads need consistent behavioral cues to maintain synchrony, and when communication channels are removed, they will quickly become decoupled. Highly similar dyads, on the other hand, can maintain stable synchrony for more time in the absence of communication.

Demonstrationsof Expressive Synchrony

Behavioral components of emotion, described above, can trigger affective synchrony. For instance, a baby's cry of distress might cause the caregiver to match the distress in some aspects of time and space, even if the caregiver does not (usually) show behavioral synchrony in the sense of bursting into tears. But increasing evidence suggests that dyads do frequently align their bodily expressions of affect, suggesting a system of expressive and physiological synchrony. Comprehensive reviews of behavioral synchrony and the closely related phenomenon of non-verbal mimicry (i.e., similarity in form but not the timing of expressive behavior) exist elsewhere (e.g., Lakin, 2013; Repp & Su, 2013; Wheatley et al., 2012). So, we focus here on the conditions under which expressive synchrony is most likely to emerge.

Expressive synchrony is most frequently observed during positive affective interactions. For instance, Riehle et al. (2017) examined the synchrony of activation of smiling and frowning muscles with methods of electromyography (EMG) while participants discussed positive and negative life events. Compared with pseudo-dyads, true dyads synchronized their smiles, as estimated using windowed cross-lagged correlation analysis. Synchronization of smiles was rapid: after one interactant smiled, their partner smiled within 200–1000 ms. Interactants' frowns did not appear to synchronize, suggesting that (previously unacquainted and gender-matched) interaction partners are more likely to synchronize positive compared with negative expressions.

Other evidence supports the notion that synchrony tends to accompany positive affect. Likowski et al. (2011) induced happiness or sadness in participants and then exposed them to images of facial expressions. Using EMG to measure participants' facial muscle activity, they found that happy participants were more likely than sad participants to align their faces to match both the positive and negative facial expressions. Mønster et al. (2016) found that smile synchrony within newly formed cooperative teams was correlated with positive team outcomes, while sympathetic nervous system synchrony (measured via skin conductance) was correlated with negative team outcomes. Such findings highlight that not all synchrony is desirable, an idea we return to later.

Dyads working toward a shared goal that requires coordination are also more likely to align their expressions of emotion. Louwerse et al. (2012) had participants perform a map task (Anderson et al., 1991) while they were videotaped. The task involved unscripted communication about particular routes. Knowledge of the route was distributed between the Instruction Giver, whose maps showed the route, and the Instruction Follower, who had to reproduce the route on a similar map. Maps showed, to different degrees, common landmarks, but some landmarks on the Followers' maps were obscured by grey "inkblots." Coders trained in the Facial Action Coding System (FACS; Ekman et al., 2002) classified participants' facial movements including not only (of interest here) signs of laughter and smiling but also manual gestures and features of the language. Findings revealed significant synchrony across modalities. In addition, some modalities, including laughter and smiling, showed higher synchrony when landmarks were more extensively obscured by the inkblots, making communication more difficult. The peak latency between one partner producing the behavior and the other partner matching them depended on the behavior, although most latencies were within a few seconds. This suggests that when communicative channels sync in cooperative interactions, it provides an embodied grounding for understanding (also see Chartrand & Bargh, 1999; Golland et al., 2019).

A role for expressive synchrony in communication was demonstrated recently in our laboratory (Zhao et al., under review). Specifically, we tested the prediction that when people interact without the use of spoken language, they become more facially expressive and these expressions become more synchronized in order to compensate for the loss of communication through the verbal channel. Working in pairs, participants took turns completing trials of four different tasks in which they could earn points, awarded to the dyad as a team. Two of the tasks, a risk-taking task and a Jenga tower-building task, were designed to elicit emotion during joint action. Importantly, pairs were assigned to either a spoken language permitted or spoken language not permitted condition. As expected, in the latter condition, in which pairs could not use spoken language, both facial expressiveness and also facial expressive synchrony were higher than in the spoken language permitted condition.

In instances of expressive synchrony where there is a clearly identifiable "leader"—for instance, during unidirectional communication—one might assume that the "synchronizer" is always temporally lagging behind the "leader." However, the synchronizer's expression can predict and precede the onset of the leader's expression. In a documentation of predictive smiling, Heerey and Crossley (2013, Study 2) estimated smile onset asynchronies, or the time lag before an individual returned genuine and polite smiles. Past research has demonstrated that people sometimes return smiles reactively with time lags longer than 200 ms, which is usually conceptualized as facial communicative mimicry (e.g., Wood et al., 2016). The researchers reasoned that synchronization within 200 ms after smile onset reflects the prediction of impending facial expressions in the partner because perceptual processing and subsequent motor output take longer than 200 ms (Sanders, 1998).

Participants in the study (Heerey & Crossley, 2013) learned to associate neutral faces with key presses, and correct responses were either rewarded with genuine or polite smiles. Participants learned stimulus–response mappings more quickly when the mappings were reinforced with genuine, compared with polite, smiles. In addition, the genuine smiles were returned predictively to a higher extent, suggesting the anticipation of social reward (e.g., a genuine smile), which has been observed in other social learning paradigms (Schultz, 2007). These findings along with those of Riehle et al. (2017), mentioned previously, provide quantitative evidence of predictive facial synchrony. They also support the earlier claim that synchrony is more common for positive signals, here manifested as genuine (as opposed to polite) smiles.

What is the relationship between expressive and physiological synchrony? We argued earlier that behavioral cues are the communicative medium through which physiological synchrony is achieved. Expressive synchrony can trigger synchrony of internal states (e.g., physiological synchrony) by continually linking partners' behavior (Feldman et al., 2011). Expressions are often an embodied manifestation of an internal physiological state and can, therefore, be an observable and transferrable mediator of physiological synchrony. In a study in which strangers watched videos together, moments of synchronous smiling (measured with facial electromyography) correlated with moments of cardiovascular synchrony (Golland et al., 2019).

Expressive synchrony establishes moments of intensive interpersonal coupling and connection. Expressive synchrony, like affective synchrony more broadly, thereby enables information exchange, co-regulation, and social bonding within the dyad. We explore these adaptive consequences next.

Functions of Affective Synchrony

What is the adaptive function of synchrony? Maybe synchrony has no function and is instead always a by-product of a simpler physical process. For instance, ticking metronomes will fall into sync if they are physically coupled via a shared surface. But we would not say that the metronomes being in sync have a *function.* Thankfully, people are more complex than metronomes. Evidence suggests that we reap a number of benefits by connecting with social partners through affective synchrony.

We propose three overlapping but specific adaptive functions of affective synchrony (see Fig. 17.1). First, affective synchrony, like other forms of interpersonal synchrony, reduces the number of uncorrelated variables (i.e., complexity) of a dyad, making information processing easier for both partners. In other words, shared affective responses reduce the number of time-varying affective response variables within the dyad from two to one. Second, by sharing their emotional states with others, people are able to detect and respond to challenges and opportunities in the environment more efficiently. The benefits of this ability can be measured on multiple timescales: at the moment, spouses can pool their resources to co-regulate each other's distress. Caregivers can instill immediate fear and freeze in a baby about to walk off a step by vocalizing their alarm. Over the long-term, affective synchrony enables social learning, as partners align with each other's responses

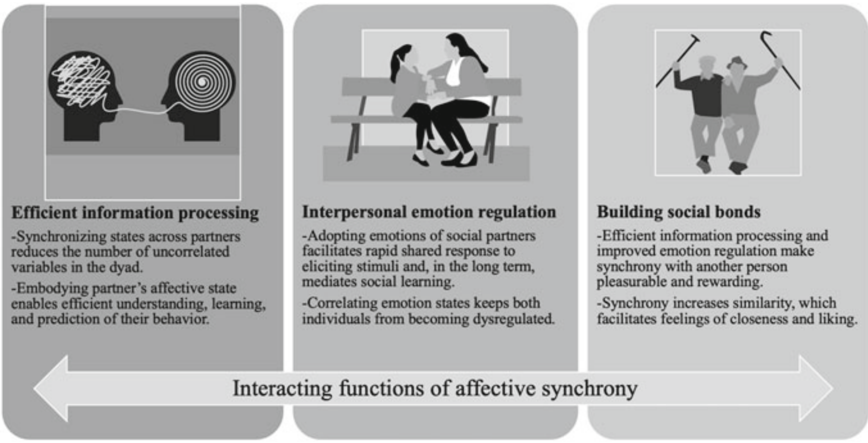

Fig. 17.1 We propose three interconnected levels at which affective synchrony is adaptive

to classes of stimuli that are encountered on repeated occasions. Finally, extensive evidence suggests affective synchrony enhances feelings of similarity and closeness and strengthens social bonds. We explore these three functions next.

Efficient Information Processing

We theorize that affective synchrony enables more efficient information processing. Koban et al. (2019) posit that, as a general rule, interpersonal motor synchronization arises as a result of the tendencies of the brain to conserve resources and optimize its representation of the environment. When interacting with a partner, people must represent both their own behavior and internal state and their partner's behavior and internal state. From the outset, the behaviors and internal states of social partners are likely to be similar: People usually choose to affiliate with similar others (e.g., Bahns et al., 2017), and close relational partners tend to share goals, often working together on tasks that require coordination. If members of an interacting dyad increasingly embody each other's emotional states and behaviors over time, they can jointly represent their own state and actions with the state and actions of their partner. Coupling these self and other representations gives each partner one less thing to keep track of, so interacting synchronously reduces cognitive effort.

Though Koban et al. (2019) focus on spontaneous motor synchronization, the same principles apply to affective synchrony. People use embodied sensorimotor simulation to understand other people's internal states and motivations in addition to their motor actions (Gallese & Goldman, 1998; Wood et al., 2016). Accordingly, coupling one's own emotional state with the representation of a partner's emotional state is an efficient way to understand the partner's emotions, just as motor synchronization is an efficient way to understand the partner's actions and intentions. Because the partners' emotions are aligned, an individual's own emotional state can be used to predict the future behavior of their partner (Friston & Frith, 2015; Heerey & Crossley, 2013; Seth & Critchley, 2013). For instance, afferent feedback to one's brain from one's smile represents a prediction about a partner's next facial expression and likely social intentions. Affective synchrony, in this case, supports interpersonal coordination. By increasing the ease and efficiency of social interactions, synchronization facilitates information processing and enhances communication between interacting partners.

Interpersonal EmotionRegulation

As humans, we share almost everything. We share living spaces and communities with people who often share our goals. We feed each other and regulate our temperatures by being close to each other. We share our microbiomes, circadian rhythms, beds, ideas, language, recipes, laundry, beliefs about cosmology, political preferences, and diseases. According to Social Baseline Theory, the human brain *assumes* that people have access to social relationships with interdependent others who share our goals and resources (Coan & Sbarra, 2015). To survive as a species, we have always needed to live and share internal states, possessions, environments, and outcomes with other humans.

Sharing begins in an extreme form: when we are infants, we are helpless and entirely reliant on our caregivers. Human infants cannot regulate their physiology on their own. They depend on caregivers to regulate their diet, temperature, and other aspects of their autonomic function. The infant first experiences physiological and behavioral codependence—and synchrony—with another human while still inside the womb. Physiological and behavioral synchrony between the infant and caregiver continues after birth, as the caregiver is closely attuned to the rhythms and needs of the infant. For instance, parents time their active caregiving to coincide with newborn's sporadic periods of alertness (Feldman, 2012).

Over the course of development, the growing infant learns to associate their behavioral and physiological states with the corresponding states in their caretaker. The infant then learns to reverse the causal relationship in order to synchronize with the caregiver to regulate itself and influence the caregiver (Atzil et al., 2018). The tight coupling of physiological and behavioral processes present in an adaptive infant–caregiver relationship sets the stage for a lifetime of interpersonal synchrony and co-regulation (this developmental trajectory for synchrony has also been observed in dolphins: Fellner et al., 2006).

Affective synchrony allows us to regulate the behavior of others, particularly when they are unable to regulate themselves (Saxbe et al., 2020). Affective synchrony allows partners to foster context-appropriate emotional states, such as achieving a state of calm prior to falling asleep. According to Social Baseline Theory, a function of the co-regulation of emotion is to render more metabolically efficient the cost of coping with the opportunities and challenges of social life (Beckes & Coan, 2011; Coan, 2008; Coan et al., 2006). Adaptive co-regulation does not always mean up-regulating positive states or down-regulating negative states. Sharing negative effect is adaptive in certain contexts; as we have seen, the sharing of stress from the mother transmits an understanding of the presence of threat in the environment to their infant (Waters et al., 2014).

Correlational evidence indirectly supports the notion that affective synchrony enables co-regulation of emotion. The degree to which mother–infant dyads achieve behavioral synchrony is positively correlated with the infant's cardiac vagal tone (Porter, 2003). It may not always be the case that the person *being* regulated is the follower. The regulating person, such as a caregiver, may first match their partner's distress, for instance becoming stressed upon hearing the infant's cry, and then bring the dyad as a single unit back to a low arousal set point.

The concept of co-regulation of affect is central to Butler's (2011) Temporal Interpersonal Emotion System (TIES) model, which proposes that in the context of social interactions, emotions can be thought of as self-organizing dynamical systems in which the components of emotions emerge and interact across interactants. In the model, co-regulation is operationalized as the bidirectional linkage of oscillating emotional channels between partners, which contributes to emotional stability for both partners (Butler & Randall, 2013). In a healthy close dyad, the oscillating activity levels in each person's physiological systems are tied to their partner's. If one person's physiological rhythm becomes dysregulated—for instance, decoupled from relevant external cues (as in the case of chronic anxiety)—their partner's well-calibrated physiological state can regulate them and bring them back to a more adaptive physiological state. For the examples of adult dyads described earlier, including romantic couples and therapeutic alliances, physiological synchrony plays a developmentally appropriate function of contributing to the co-regulation of emotional responses (Liu et al., 2013; Papp et al., 2013; Saxbe & Repetti, 2010).

In a functioning dyad, partners adjust synchrony according to their own needs and resource availability. The amount of affective synchrony a caregiver–infant dyad achieves is a function of how much co-regulatory support the infant needs and how much co-regulatory support the caregiver is able to provide. A recent study examined the relationship between infant–mother behavioral synchrony and parasympathetic nervous system (PNS) and SNS activity during the mildly stressful still face paradigm (Busuito et al., 2019). Babies with lower PNS activity—infants who might need greater co-regulatory support—elicited more synchronous behavior from their mothers. Mothers who engaged in more synchrony, on the other hand, had *higher* PNS activity. The authors concluded that these less-aroused mothers were more able to attune to and regulate their babies' distress, perhaps because they had greater emotional resources available to them.

Affective synchrony does more than allow partners to influence each other's in-the-moment affective states. It also helps them teach each other adaptive patterns of emotional responding, which we might consider a long-term manifestation of co-regulation. Social animals use the experiences of others as a source of information about the local environment—for example, which foods are safe to eat and which animals are dangerous (Barrett & Broesch, 2012). If a group of people are in the same environment and have similar goals, it would be inefficient for each one to appraise the environment and its threats and opportunities separately. By yoking their expressions and physiology, they share emotions, which guide and motivate coordinated responses to threats and opportunities. The capacity to synchronize affective responses with others promotes efficient and adaptive responding to stimuli, perhaps before one has even had a chance to appraise them, which is one of the metabolic hallmarks of social learning (Gilbert et al., 2009).

A number of non-human animal groups exhibit the beneficial effects of sharing behavioral responses conferred by embodying each other's expressions and experiences of emotion in the form of affective synchrony. Animals living in groups across phylogeny produce alarm calls when they detect a threat, efficiently spreading their heightened arousal and vigilance to the rest of the group (Snowdon, 2003). The efficiency of this strategy depends on the rest of the group immediately embodying the affective state of the alarm caller—if all group members had to independently detect the threat before acting, it might be too late. Affective states are indeed contagious across animals regardless of whether all group members actually detected the relevant stimulus. For instance, when a stressed zebrafish is placed in a tank with a second non-stressed zebrafish, the fish "average out" their affective states and both become moderately stressed (Crane et al., 2018). The fish pool information about the environment by synchronizing their affective states through observable cues may be visual, olfactory, or otherwise.

Humans similarly share their affective states and the accompanying behavioral responses to evocative stimuli. For instance, as described above, Waters et al. (2014) reunited infants with their mothers after the mothers were exposed to a stressful situation. Infants aligned their states to the heightened arousal state of their mothers, even though they were not directly exposed to the stressor. This affective synchrony was achieved largely through touch (Waters et al., 2017). The adaptive benefits of such affective co-regulation are clear. By sharing her affective response with the infant, the mother is guiding the infant's behavior (see also Vaish & Striano, 2004). Indeed, the researchers found that the babies behaviorally avoided the person who caused the stress in their mother, even though that person had not done anything to threaten them directly (Waters et al., 2014). The child also learns how to respond to similar stimuli in the future (Skinner et al., 2019). As these examples illustrate, affective synchrony is a general mechanism for social learning (Klinnert et al., 1983).

Building Social Bonds

As we have shown, synchronizing with a partner is efficient. Merging one's representation of one's own state and actions with one's representation of a partner's state and actions reduces cognitive effort, so partners can process the unfolding interaction with greater ease. In general, processing fluency feels good and leads to positive evaluations (Reber et al., 1998). Because synchronous interactions afford savings in effort and energy consumption, they feel easy and rewarding. People feel good when they are "in sync" with an interaction partner.

Perhaps due to the pleasant feelings that accompany being in sync, synchrony is also linked to positive social outcomes. Behavioral and vocal synchrony increase prosocial behavior, perceived social bonding, and positive affect (Mogan et al., 2017). Moving synchronously with social partners leads people to perceive themselves as more similar and increases feelings of compassion and willingness to help (Valdesolo & DeSteno, 2011). Being in sync also induces feelings of closeness and connection (Sharon-David et al., 2018), even in groups (e.g., Jackson et al., 2018; Launay et al., 2016).

Of course, many empirical demonstrations linking synchrony to prosociality and rapport rely on brief manipulations in which experimental dyads are led to produce synchronous motor behavior such as tapping, clapping, or rocking. We expect that aligning the form and timing of emotional expression and physiology with relational partners in the real world feels at least as intimate as tapping a beat in time with a stranger in a lab experiment. Indeed, Páez et al. (2015) found that people who reported having felt in synchrony with others in naturalistic settings, including a joyful folkloric march and a negatively charged political demonstration, felt greater social support and stronger emotional involvement. Such findings suggest that sharing emotions in real time with another person signals that one's interaction partner is similar to us and likely shares our goals; after all, both are appraising (and preparing to act on) the environment in the same way.

Affective synchrony may also be rewarding because influencing each other's emotional states is pleasurable in itself. When a person smiles and they receive a smile in return, they experience emotional self-agency, or the feeling of having caused the partner's emotions. The process establishes a general feeling of a causal connection and reciprocal influence through cycles of non-verbal communication (e.g., Feldman, 2011). Heightened emotional self-agency has important benefits (Feldman et al., 1999). The benefits can be temporary: when individuals experience themselves as the cause of another's joy, they will likely continue to perform similar behaviors. The consequences are also long term: individuals with a general sense of emotional self-agency have higher social and emotional outcomes overall.

In sum, behavioral and affective alignments are pleasurable and cause partners to feel close, motivating them to continue to interact over time. The feelings of ease, self-agency, and rapport experienced during synchronous interactions reward the interacting partners, strengthening the bonds between them.

Costs of Affective Synchrony

Co-regulation, ease of information processing, and building of social bonds are the proposed functions of affective synchrony. But even functional behaviors can be dysfunctional if they are insensitive to context. Constant, perfect synchrony is maladaptive (Mayo & Gordon, 2020). After all, if partners perfectly matched each other, they would be unable to benefit from having two brains and bodies rather than one. Moments in which synchrony is beneficial are complemented by moments in which independent behavior is beneficial (Koban et al., 2019; Sebanz et al., 2006; Skewes et al., 2015). Indeed, synchrony tends to occur less than half of the time in a functioning dyad (Feniger-Schaal et al., 2016; Noy et al., 2011).

Mayo and Gordon (2020) refer to dyadic synchrony as a "meta-stable" phenomenon, meaning the dyad does not stably maintain a constant synchronous state, but rather the flexible ability to alternate between synchronous and independent behavior. We have already seen evidence that dyads calibrate their affective synchrony to fit the demands of the interaction (Zhao et al., under review). Danyluck and Page-Gould (2019) demonstrated that PNS and SNS synchrony depend on whether dyads are engaged in a cooperative or competitive context as well as the extent to which they are allowed to interact (see also Miles et al., 2010; Paxton & Dale, 2013).

Affective synchrony within a dyad can be maladaptive when the shared state is negative, and the partners amplify and escalate their unpleasant emotion. In dyads that effectively co-regulate each other, the negative emotion of one person is counterbalanced by their partner, returning the dyad to their set point (Reed et al., 2015). Parents, for instance, tend to decrease their physiological arousal when the infant's arousal is heightened (Wass et al., 2019). But in dyads that are dysregulated, the negative emotion of one partner is reinforced by the other's, creating a positive feedback loop of heightened distress.

Growing evidence supports the insight that synchrony during negative affective states is often maladaptive (Saxbe et al., 2020). Romantic partners discussing loss and bereavement showed a negative correlation between heart rate synchrony (indicating shared negative arousal) and feelings of compassion (Corner et al., 2019). In other words, being a supportive partner during a distressing conversation entails *not* synchronizing with the other person's physiology. Vocal pitch synchrony in client–therapist dyads is associated with worse therapeutic relationships and greater client distress (Reich et al., 2014). In the therapeutic relationship, then, synchrony to achieve and convey empathy must be tempered, lest the therapist amplifies the client's distress by reflecting it back to them. Anxiety about the ongoing interaction can also be transmitted from one partner to the other: in a cross-race interaction, a White partner's interracial anxiety can make their Black partner more anxious (West et al., 2017).

While the tendency to match the positive emotions of others is associated with well-being and sympathetic caring, the tendency to match the negative affective states of others is associated with emotional distress and personality disorder symptomatology (Murphy et al., 2018). Mothers with depression synchronize more with their babies during negative states than do mothers without depression (Field et al., 1990). Rather than co-regulating the baby and helping it learn how to handle its distress, this dysregulated form of synchrony may heighten and reinforce the baby's distress.

Suveg et al. (2016) measured the heart rate synchrony of mothers and their 3-year-old children during an interactive Etch-a-Sketch task and a control period (in which the pair sat quietly). Physiological synchrony was present during the interactive task and such synchrony predicted the child's ability to self-regulate. Of note, this effect was not observed for a subsample of families that were at high risk, suggesting that the achievement of synchrony can be disruptive to other processes if physiological responses to social contexts are inappropriate or dysregulated.

We posit that context-insensitive affective synchrony is further maladaptive because it disrupts individuals' emotional functioning. The more partners' affective states influence each other, the less they will be influenced by factors outside the dyad. The dyad will, therefore, be necessarily less emotionally responsive to salient events in the environment. Adaptive emotional responding is flexible and tuned to external events (Schuyler et al., 2014). Preliminary evidence suggests interpersonal synchrony may in fact impede self-regulation (Galbusera et al., 2019). Synchrony can also strengthen in-group bonds to the detriment of intergroup relations, providing further evidence that the benefits are context-dependent (Tamborini et al., 2018).

Besides falling into emotion dysregulation, a dyad that is inflexibly synchronized may suffer information processing disadvantages (in contrast to the information processing advantages of synchrony discussed in an earlier section). Social groups afford informational advantages to group members, as the members can crowdsource perception, prior knowledge, and decision-making (Bietti & Sutton, 2015). But part of those advantages come from the information processing diversity of the group (e.g., Derex & Boyd, 2016), including diversity in their emotional responding. If social partners react identically to all events because they are synchronized, they lose some of that advantageous diversity. Behavioral synchrony in a dyadic problem-solving task was negatively associated with overall performance (Abney et al., 2015). We suggest extreme affective synchrony, beyond mere behavioral synchrony, might have similar drawbacks. In line with this reasoning, Mønster et al. (2016) found that physiological synchrony among cooperating team members was positively related to team cohesion but negatively related to a team's likelihood of adopting a new (potentially more optimal) task behavior over multiple sessions. The teams that synchronized excessively, rather than flexibly switching between synchrony and independence, did not benefit from having multiple minds working to solve a problem.

To summarize, affective synchrony is not always a good thing. When dyads synchronize regardless of context, including during negative affective states, they lose some of the co-regulatory and information processing benefits of being social.

Paths for Future Research

In the present chapter, we have integrated a large body of research that explores a particular form of embodying emotions. Rather than momentary embodiments of emotion, such as an act of facial mimicry, the concept of synchronous emotions entails the matching of expressive cues to emotion and the corresponding matching of physiological activity over real time. We have called "synchronous" those conditions in which the matching of components of emotion represents several mathematical functions including those of covariation and correlation as well as more formal oscillation. However, this matching concept has been named by many different terms in the literature including alignment, entrainment, mimicry, mirroring, imitation and, of course, synchrony.

Future theorizing, modeling, and research will need to formalize the different manners of interpersonal matching of emotions over time. There are almost as many ways to quantify synchrony as there are definitions of the term (e.g., Butler, 2011; Moulder et al., 2018; Thorson et al., 2018). Each has its own assumptions and aims to model slightly different things. A systematic set of quantitative recommendations and an account of their uses and meanings are now sorely needed for progress in further understanding the forms and functions of affective synchrony.

A deeper understanding of the costs and benefits of affective synchrony will require an additional type of modeling, which is the modeling of synchrony itself over time. For example, while we have noted that some costs of affective synchrony are observed during states of negative emotion, it could be that synchrony is initially beneficial in supporting the understanding of even another person's negative emotions, but that a divergence from synchrony—a decoupling—is then beneficial because it aids in dyadic emotion co-regulation and the use of contextual information. That is, there may be an important difference between initial synchrony and synchrony that is "stuck" in a negative cycle or state of escalation.

Finally, the precise relationships between the synchronization of different components of emotion, including expressive cues, peripheral physiology, and neural states await further study.

Conclusion

The forms and functions of interpersonal synchrony are a rapidly expanding topic of psychological research, thanks to ever-improving measurement and analysis methods (Moulder et al., 2018; Zhao et al., under review). Affective synchrony shares many properties attributed to interpersonal synchrony more generally, such as its potential to reduce interpersonal degrees of freedom (Koban et al., 2019). But affective synchrony also exhibits some unique properties compared with pure motor synchrony. It allows dyads to co-regulate each other, learn appropriate emotional responses, engage in empathy-related simulation processes, and strengthen their bonds. As with other forms of interpersonal synchrony, affective synchrony is most adaptive when dyads flexibly synchronize at relevant moments in an interaction (Mayo & Gordon, 2020).

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