Alternatives to Collective Rituals: Synchronous Actions in Secular Contexts and Their Mechanisms

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Abstract

Secular social life synchronous actions constitute a cross-cultural universal phenomenon that possesses prosocial functions equivalent to those of collective ritual synchronous actions. In establishing social connections and enhancing mental health, social life synchronous actions can partially substitute for collective rituals in exerting psychological protective effects on individuals and groups. From perspectives such as movement phase, level of consciousness, and coordination mode, social life synchronous actions can be categorized into five types, with different types exhibiting both similarities and differences in their relationships with social response factors and mental health, as well as in their underlying psychological and physiological mechanisms. Future research should further elucidate the substitutive and compensatory nature of social life synchronization for collective ritual synchronization, investigate the influence of factors such as level of consciousness and movement phase on synchronization effects, and focus on the functions and mechanisms of different types of synchronous actions.

Full Text

A Substitute for Collective Rituals: Synchronized Movement and Its Mechanisms in the Secular World[1]

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Abstract

Social life synchronized movement in the secular world is a cross-cultural universal phenomenon that shares the same pro-social function as collective ritual synchronized movement. In establishing social bonding and improving mental health, synchronized movements in social life can, to a certain extent, replace collective rituals and play a psychologically protective role for individuals and groups. From the perspectives of movement phase, consciousness level, and coordination mode, synchronized movements in social life can be divided into five types, and there are similarities and differences in the relationships between different movement types and social response factors, mental health, as well as their psychological and physiological mechanisms. Future research should further reveal the substitutive and compensatory nature of social life synchronization for collective ritual synchronization, examine the influence of factors such as consciousness level and phase on synchronization effects, and focus on the functions and mechanisms of different types of synchronized movements.

Keywords: social life synchronized movement, collective ritual, social bonding, mental health

Synchronized movement is ubiquitous in human life and constitutes a core element of collective rituals (Whitehouse & Lanman, 2014). However, synchronized movement is not confined to collective rituals; it is also commonly observed in secular social life contexts. Synchronized movement in the secular world represents a universal feature of social life and a fundamental component of human society (Marsh et al., 2009). From the perspective of synchronized movement' s emphasis on matching periodic behaviors with identical frequency and/or cycle (Reddish et al., 2014) and its coordinated consistency (Zou Xiaoyan et al., 2018), secular synchronized movement indeed resembles that of collective rituals. Yet social life synchronized movement lacks the causal opacity characteristic of collective rituals and is not embedded within the symbolic meaning of rituals.

Ancient humans lived in tribes and villages, and apart from collective rituals associated with religious beliefs, they created numerous synchronized activities for daily group participation. For instance, synchronized movements are common in folk collective dances across China' s ethnic groups. The Yi ethnic dance "Left Foot Dance," recognized as a national intangible cultural heritage, involves anywhere from seven or eight to several hundred dancers who all begin with their left foot in rhythm with the Yi characteristic instrument, the dragon-head four-stringed lute. Although the dance steps of Left Foot Dance are varied and diverse, all co-dancers complete the steps according to the same rhythm and sequence. Similarly, while the Dai people' s Ganyang Dance and the Jingpo people' s Munao Zongge Dance differ in steps and music, they all result from synchronized movements among folk collective dancers. With urbanization, contemporary individuals participate less in collective ritual activities, yet synchronized movements in social life, such as square dancing and military parade marching, remain prevalent and vibrant. To some extent, social life synchronized movement has played a substitutive and compensatory role for the loss of cultural protective factors for human social adaptation and mental health caused by the decline of traditional collective rituals. Mogan et al.' s (2017) meta-analysis of 42 synchronized movement studies demonstrated that synchronized movement enhances various social response factors, including pro-social behavior, perceived social bonding, social cognition, and emotion, to varying degrees.

Additionally, numerous studies have confirmed that synchronized movement promotes positive emotion (Gabriel et al., 2020), subjective well-being (Páez et al., 2015), and reduces work-related stress (Göritz & Rennung, 2019). Investigating the psychological mechanisms of social life synchronized movement and its positive psychological effects is not only beneficial for understanding the development and progression of human civilization itself but also represents a crucial issue for the innovative transformation of traditional culture to continue maintaining individual mental health.

1.1 Differences Between the Two

First, collective ritual synchronized movement exhibits greater rigidity and redundancy than social life synchronized movement and possesses symbolic meaning that the latter lacks. Collective ritual synchronization has a compulsory characteristic, requiring specific rituals to be performed at particular times; otherwise, participants perceive their situation as dangerous (LiÉNard & Boyer, 2006). Repetition itself is not the motivation for collective rituals but rather a strict regulation—a fixed behavioral pattern (Tonna et al., 2020). The symbolic meaning of collective ritual movements is typically embodied in both the executed actions and various group symbolic signs, such as the ancient military uniforms worn by "walkers" in folk religious processions, as well as flags and icons. The specific spatial configurations presented in collective ritual synchronization also often carry symbolic significance; for instance, the circular dance structure common in ancient tribal group dances symbolizes unity and equality. In contrast, social life synchronization does not require intense concentration on fixed sequences of movements or repetitive identical actions and is not constrained by time or space. It can involve either self-created novel movements or common everyday actions; the movements themselves lack symbolic meaning and are not embedded within any symbolic framework—the movement itself is the purpose.

Additionally, the ecological and social functions of the two differ. Ecological function refers to managing interactions between species and their environment, emphasizing responses to unpredictable natural stressors, whereas social function pertains to social interaction and communication between species, focusing on the adaptive role of social relationships (Lang, 2019). Collective ritual synchronization emphasizes ecological function; its occurrence relates to brain development and evolution, resulting from interactions among neural circuits, neurotransmitters, and synapses that lead to repeated identical actions (Tonna et al., 2020). Collective ritual synchronization appears in the ecological environments of animals, including humans. Humans perform collective ritual synchronization often with intentions such as cleansing the body, warding off disease, or escaping drought. Social life synchronization emphasizes social function, highlighting its promotional effect on social bonding and pro-social behavior. Social life synchrony appears to be innate or learned in the womb. Fetuses receive auditory stimulation from their mother' s heartbeat in the womb (Chorna et al., 2019), beginning perceptual synchronization training. Infants, under rhythmic auditory stimulation, enhance limb synchrony through auditory feedback, consequently exhibiting more regular movements (Shinya et al., 2022). Synchronization experiences enable children to learn to share emotions and infer others' emotions (Atzil & Gendron, 2017), and as adults, they exhibit more pro-social behavior (Cirelli, 2018). This suggests that synchronized movement may be a product of associative learning that enhances people' s adaptive capacity in social interpersonal relationships.

1.2 Social Life Synchronized Movement as a Substitute for Collective Rituals

Both collective ritual synchronized movement and social life synchronized movement have been demonstrated to have positive effects on social response factors and mental health. Compared with collective ritual synchronization, social life synchronization imposes fewer restrictions on participant qualifications, time, and space, and maintains more relaxed requirements for movement repetition and fixed sequences. This enables social life synchronized movement to substitute for collective rituals in establishing social bonding and improving mental health, thereby playing a psychologically protective role for individuals and groups.

Durkheim' s ritual theory proposes that collective ritual synchronization is a symbolic activity with two primary functions: first, an external function that increases performers' loyalty to the group (Watson-Jones & Legare, 2016). Participating in collective rituals represents a high-cost activity requiring time and resources, and such participation demonstrates commitment to the group more effectively than verbal expression (Lang, 2019). Second, an internal commitment that increases performers' personal attachment to the group (Stein et al., 2021). These two functions facilitate the development of trust among team members. Previous research on collective ritual synchronization has typically been conducted in contexts with symbolic meaning, where participants experience a sense of sacredness and self-transcendence after performing synchronized movements. For example, participants who recalled and wrote about synchronized movement experiences in churches, concerts, or weddings reported a sense of sacredness known as collective effervescence (Gabriel et al., 2020). Research on Spanish patriotic military parades found that collective ritual synchronization not only increased participants' positive collective emotional experiences, such as awe, hope, and morality, but also evoked negative collective emotions, including anger, hatred, and collective shame (Páez et al., 2015).

Research on social life synchronized movement often assigns participants to different operational levels (e.g., synchronized and non-synchronized), requiring synchronized participants to perform either a novel set of movements or common synchronized movements from daily life, such as dancing or singing. Such studies have confirmed the positive promotional effects of social life synchronization on social response and mental health. For instance, when participants performed a simple warm-up routine designed by researchers according to beats played through headphones, synchronized movement was found to promote social bonding (Davis et al., 2015). In another study where participants collectively sang while ensuring they did not know each other, synchronized singing increased pain threshold and positive emotion (Pearce et al., 2015). Researchers have primarily employed neurobiological theory, affective theory, attention theory, and the blurring-of-self model to explain the mechanisms underlying the positive psychological effects of social life synchronization. Among these, neurobiological theory has been widely used to explain the psychological effects of synchronized movement and has received substantial support. This theory posits that synchronized movement activates the endogenous opioid system, releasing endorphins that consequently promote social bonding and other factors.

Social life synchronization is regarded as a substitute for collective ritual synchronization and has become a cross-cultural universal phenomenon. This represents an indirect result of natural selection and evolution—a specific human adaptive behavior that facilitates individual social interaction and is even crucial for human survival and reproduction (Barry, 2019; Berecz et al., 2020). In addition to sharing similar functions with collective ritual synchronization in social response and mental health, social life synchronization does not accompany ritualized sequential movements and breaks through limitations of time, space, and geography. It tends toward automatic movement without requiring concentrated attention on the movement itself, representing a low-cost social activity. This, in turn, explains the universality and retention of synchronized phenomena such as secular collective dancing, military training, and group singing across all human societies. Even in modernized societies, where ancient traditional collective rituals cannot completely disappear, modern individuals clearly find it difficult to rely on these rituals to enhance intra-group bonding and even more challenging to address bonding between different groups. Therefore, in the absence of collective rituals, social life synchronization plays a certain substitutive or compensatory role in promoting people' s social bonding, pro-social behavior, and mental health.

2.1 Evolution of Synchronized Movement Concepts

Early researchers distinguished between movement forms similar to synchronization. For instance, Condon and Sander (1974) identified two forms of synchronization: self-synchronization and interactional synchronization. The former refers to the integration of an individual' s own behaviors, including temporal consistency between bodily movements and vocal tone, while the latter denotes synchronization of different individuals' behaviors in rhythm and time—namely, synchronized movements in collective rituals or social life. Bernieri (1988) divided movement coordination into behavioral matching and movement synchronization, with the former emphasizing similarity of movements at certain time points without requiring precise external movement matching, and the latter referring to simultaneous motor behavior that emphasizes consistency in both form and temporal alignment.

Subsequently, researchers who considered coordination an indispensable prerequisite for good social interaction proposed two concepts: movement matching and interpersonal synchronization (Bernieri & Rosenthal, 1991). Movement matching primarily refers to individual imitation of movements, whereas interpersonal synchronization involves mutual coordination between different individuals. Does synchronized movement require both movement matching and interpersonal coordination? One perspective holds that synchronization involves less interpersonal interaction than coordination, meaning that the rhythm and frequency of synchronized movement itself are fixed (Helm et al., 2012). Another view considers synchronized movement as a temporal mutual adaptation of behaviors between interactants—a dynamic phenomenon (Delaherche et al., 2012). Individuals in groups synchronize their movements, thoughts, attention, and mental states in a coordinated manner (Ackerman & Bargh, 2010). Richardson et al. (2007) view synchronized movement as the frequency and state shared by different individuals in social interaction, whereby group members maintain temporal consistency in movement and state, manifesting similar movement and state patterns. These perspectives essentially imply that synchronization and coordination are not···Current researchers propose that the meaning of synchronized movement has both narrow and broad definitions. The narrow definition refers to different individuals maintaining movement synchronization, while the broad definition encompasses multi-channel sensory synchronization, including not only specific movements but also emotions and cognition (Rennung & Görit, 2016). The broad definition even generalizes to physical and physiological levels (Mazzurga et al., 2011). Recent research indicates that scholars more frequently adopt the narrow definition, referring to the matching trend of behaviors between individuals at identical times and/or cycles (Jackson et al., 2018; Reddish et al., 2014). This emphasizes consistent movement matching among group members while treating the adjustment of interaction partners' emotional states and mutual attention—namely, emotional sensitivity and social cognition in interpersonal coordination—as psychological mechanisms through which synchronized movement influences social response factors.

2.2 Classification Criteria and Corresponding Types of Synchronized Movement

Cuadros et al. (2020), in their study on synchrony in spontaneous and non-spontaneous interactions between infants and adults, noted that using the single term "synchronization" encompasses both micro- and macro-level coordination phenomena, necessitating conceptual differentiation. This research suggests that distinctions must be made regarding the similarities and differences among various social life synchronized movements in terms of external features or internal mechanisms. Synthesizing the characteristics of different types of social life synchronized movements addressed in previous research, this study proposes the following criteria or perspectives for classifying synchronized movements and lists their corresponding types:

2.2.1 Common or Novel Synchronized Movements

Based on whether the executed synchronized movements are common in daily life or created by researchers, synchronized movements can be divided into common and novel types. Existing research has frequently employed common synchronized movements from daily life, such as dancing together (Tarr et al., 2017), clapping (Gabriel et al., 2020), marching (Páez, 2015), and speaking (Von Zimmermann, 2016). Studies have also utilized novel synchronized movements with innovative characteristics—specific movements designed by researchers themselves, such as maintaining consistent beats together (Hove & Risen, 2009) or shaking objects together (Richardson et al., 2007). In reality, to enhance the internal validity of synchronized movement research, both common and novel synchronized movements differ from authentic synchronized movements in human daily life. For example, Reddish et al. (2013) employed a common synchronized movement—dancing—with an execution time of six minutes and participants who did not know each other. In contrast, collective singing and dancing in real life may last longer, involve familiar members with shared group identity, and typically include marked group symbols such as similar clothing, familiar dances or music, and lyrics representing the group' s unique attributes.

2.2.2 Synchronized Movements with Different Phases

Based on phase differences, synchronized movements are divided into two movement phases—in-phase and anti-phase synchronized movements (Sullivan & Blacker, 2017). In-phase synchronized movement occurs when two individuals are completely identical (0 degrees), whereas anti-phase synchronized movement involves alternating movement patterns between two individuals (180 degrees), with frequency locked but phase unlocked. For example, when two people perform squats side-by-side, their simultaneous squatting and standing constitutes in-phase synchronization; when one person squats down while the other stands up, this constitutes anti-phase synchronization. Current research indicates that walkers perceive the highest degree of harmony when the phase relationship between their steps is either "in-phase" (completely synchronized movements) or "anti-phase" (each individual' s movement occurs at opposite points of the movement cycle simultaneously) (Miles et al., 2009). Both in-phase and anti-phase synchronized movements represent stable coordination patterns, though in-phase synchronization is generally considered more stable than anti-phase synchronization (Macrae et al., 2008). Compared with anti-phase synchronization, research on in-phase synchronization is more extensive. Although anti-phase synchronization is a common form of collective activity, it has not been definitively proven to produce synchronization effects.

2.2.3 Synchronized Movements with Different Consciousness Levels

Based on whether synchronized movements are purposeful and require volitional participation, they can be divided into conscious and unconscious synchronization. Synchronized movements typically appear in group form during collective activities. When individuals' behaviors within the group proceed rhythmically and planfully at the same stage under top-down control, this constitutes conscious synchronization. For example, dancers in a dance troupe coordinate their limb movements with musical rhythm to achieve uniform dance movements (Keller et al., 2014). Unconscious synchronization occurs when people are unaware or do not plan, though after it occurs, the phenomenon gradually becomes apparent to them. Unconscious synchronization is also called spontaneous synchronization (Néda et al., 2000). It can even occur without instruction, involving control of movement and respiratory rhythms (Codrons et al., 2014). Examples include unintentionally synchronized walking paces (Cheng et al., 2020) and rhythmic clapping together at concerts (Néda et al., 2000). Research has shown that even when obstacles are used in tapping tasks to interfere with participants' tapping speed and frequency, making their tapping trajectories differ from other participants, spontaneous synchronization eventually occurs (Lorenz et al., 2014).

Under conscious synchronization conditions, individuals are explicitly required to synchronize with given cues. In contrast, spontaneous synchronization involves the formation of spontaneous synchrony between individuals and rhythmic stimuli, primarily occurring through one or multiple sensory systems that mediate visual, auditory, or tactile information (Felsberg & Rhea, 2021). Research indicates that spontaneous synchronization differs from conscious synchronization in both temporal and morphological dimensions. Compared with spontaneous synchronization, induced conscious synchronization demonstrates higher precision in temporal and movement consistency—that is, the synchrony of conscious synchronization exceeds that of unconscious synchronization (Cuadros et al., 2020).

2.2.4 Synchronized Movements with Varying Numbers of Interaction Partners

When executing synchronized movements, the scale of interaction partners relates to the level of team synchrony (Weinstein, 2016). Based on the number of synchronized individuals and interaction characteristics, synchronized movements can be divided into dyadic synchronization, multi-person synchronization, etc. Multiple studies have categorized synchronized movements into small-group and large-group synchronization based on the scale of the performing group. In research, small groups for synchronized movements typically include 2 people (Baimel, 2018; Rabinowitch, 2017) or 3 people (Wiltermuth, 2009), while large groups consist of 12 people (Lewis, 2018). The division of large groups as 12 people is because this represents a generally reasonable group size in sports contexts (Moreland et al., 2018). However, group size can also be defined according to actual research populations; for example, in one study by Weinstein (2016), the large group comprised 232 people, while small teams ranged from 20 to 80 people.

2.2.5 Synchronized Movements with Different Coordination Modes

Synchronized movements can also be divided into internal and external synchronization. Internal synchronization includes unidirectional and bidirectional synchronization. Unidirectional synchronization typically involves individuals unilaterally adjusting their own movements to adapt to another person' s movements, whereas bidirectional synchronization is achieved through a process of giving and receiving, with individuals mutually adjusting their movements to achieve synchrony (Cacioppo et al., 2014). During group exercises, team members unilaterally adjust their movements to maintain synchronization with the lead exerciser ahead; in dance, performers must not only keep up with the music promptly but also coordinate each other' s movements to promote synchrony—the former represents unidirectional synchronization, the latter bidirectional synchronization. Research indicates that the give-and-take of synchronized dancing between mother and child helps develop children' s self-regulation (Bell, 2020). In external synchronization, individuals do not depend on each other' s movements but rather synchronize their actions through an external stimulus. For example, synchrony between individuals can be controlled by generating beats through a metronome (Hove et al., 2009).

The above five categories of synchronized movements represent classification results from different perspectives only. When integrated, a particular synchronized movement may constitute a collection of certain features from different synchronization types. For example, the specific movement of dance can be in-phase or anti-phase, spontaneous or conscious, dyadic or multi-person interactive, and internal or external. However, in the practical operation of synchronized movement research, investigators often focus on examining only one type of synchronized movement according to their research objectives.

3 Psychological Effects and Psychophysiological Mechanisms of Synchronized Movement

Current research on synchronized movement demonstrates that different types of synchronized movements exert positive or negative psychological effects on participants' pro-social behavior, social bonding, and other social response factors, as well as mental health. Researchers have employed multiple theories to explain and investigate these synchronized psychological effects and their psychophysiological mechanisms. Compared with collective ritual synchronization, social life synchronization imposes fewer restrictions on participant qualifications, time, and space, and maintains more relaxed requirements for movement repetition and fixed sequences, enabling social life synchronized movement to substitute for collective rituals in establishing social bonding and improving mental health, thereby playing a psychologically protective role for individuals and groups.

3.1 Psychological Effects and Psychophysiological Mechanisms of Common or Novel Synchronized Movements

Synchronized movement constitutes the foundation of social bonding and is ubiquitous in nature (Von Zimmermann & Richardson, 2016; Ma Xinyue, Cui Liying, 2022). Synchronized activities such as dancing, speaking, drumming, and exercising together are common in social life. Among these, synchronized dance has received the most research attention as it involves synchronization with both other people and music, helping to build group cohesion (Tarr et al., 2014). When dance movements require greater effort, they produce higher levels of social bonding (Tarr et al., 2015). Lang et al. (2017) found that cooperation levels were higher under high-synchronization drumming conditions compared with low-synchronization conditions, with endorphins released by the endogenous opioid system mediating this process. Von Zimmermann and Richardson' s (2016) research demonstrated that synchronized collective speaking can increase liking among group members, with participants in the synchronized speaking condition scoring highest on memory tests. Additionally, completing synchronized clapping and synchronized laughter while collectively watching videos enhanced positive emotional experiences and promoted mental health (Gabriel et al., 2020).

Researchers of common or novel synchronized movements often employ affective theory to explain the effect of synchronized movement on positive emotion. When individuals gather to perform highly synchronized specific movements, the collective is perceived as cohesive. Marsh et al. (2009) argue that this is because closely coordinated movements suggest a degree of positive emotion to participants, leading to complex synchronized movements. Additionally, the hive hypothesis offers a corresponding explanation, proposing that synchronized movement can bring positive affect through the intense pleasure derived from hive-like activities (Haidt et al., 2008). Thus, both affective theory and the hive hypothesis explain the role of synchronized movement in social response and mental health from the perspective of positive emotion.

Further research has explained the physiological basis of positive emotion generation in such synchronized movements. Under synchronized movement conditions, participants' endorphin release increases, enhancing positive emotion and consequently promoting social response factors such as social bonding. Neurobiological theory emphasizes the role of the endogenous opioid system in synchronized movement' s effect on social bonding, with endorphins participating in this process. Endorphins have a dual function, providing not only feelings of pleasure and happiness but also pain relief (Launay et al., 2016). Due to endorphins' analgesic effects, previous research has used pain threshold as an indicator of endorphin changes. Studies have demonstrated that synchronized dance groups exhibit elevated pain thresholds and greater social intimacy compared with non-synchronized groups (Tarr et al., 2017). Dunbar et al. (2012) directly explained the positive affect generated in social bonding activities through endorphin release. After individuals engage in synchronized activities, endorphin release promotes social bonding (Dunbar et al., 2016).

3.2 Relationship Between Different-Phase Synchronized Movements and Social Response Factors and Their Physiological Mechanisms

Different-phase synchronized movements have different advantageous effects on participants' psychology. Research indicates that in-phase synchronization may play an important role in social bonding and pro-social behavior, whereas anti-phase synchronization holds advantages in memory and learning. Compared with anti-phase synchronizers, in-phase synchronizers exhibit higher social cohesion (Wilson & Gos, 2019). Miles et al. (2010) found that participants under anti-phase synchronization conditions displayed self-memory advantage (i.e., memory about self greater than memory about others), which diminished when participants transitioned from anti-phase to in-phase synchronization.

Phase-based synchronized movement research has focused on examining the physiological basis of endorphin release in promoting participant cohesion. Many researchers believe that in-phase synchronization' s ability to promote cohesion may result from endorphin release (Tarr et al., 2017; Tarr et al., 2016). Sullivan et al. (2014) investigated three conditions: solo rowing, in-phase synchronized rowing, and anti-phase synchronized rowing. Results showed that pain thresholds under in-phase synchronization conditions were significantly higher than under the other two conditions, while anti-phase synchronization did not produce synchronization effects. Considering that anti-phase synchronized rowing is unconventional in rowing sports, subsequent researchers designed synchronization activities as solo drumming, in-phase synchronized drumming, and anti-phase synchronized drumming, finding that anti-phase synchronization produced the most significant pain threshold changes (Sullivan & Blacker, 2017). Researchers suggest that anti-phase synchronized drumming movements may be more engaging than in-phase drumming; in-phase synchronization may merely involve imitation, whereas anti-phase synchronization represents a goal-directed joint movement that produces significant effects on endorphin activity. This represents the first discovery of synchronization effects in anti-phase synchronization, also indicating that synchronized movements of different phases can influence social response factors. In commonly performed anti-phase synchronized activities such as drumming, international ballroom dancing, military bands, and boxing, synchronization effects appear more pronounced.

The blurring-of-self model explains why in-phase synchronized movement is closely associated with social response factors. This model posits that when people engage in synchronized movement, boundaries between self and others become blurred, consequently creating a sense of unity within the group (Hove, 2008). This blurring can occur whenever movements between individuals are completely matched (Decety & Sommerville, 2003), meaning the degree of boundary blurring between self and others may depend on the phase of synchronized movement. In-phase synchronization locks both frequency and phase, whereas anti-phase synchronization shares the same frequency but different phase, with the former exhibiting higher movement matching than the latter. This implies that similar neural networks in the brains of in-phase synchronizers are activated simultaneously in perception and behavior with greater precision. The blurring of self and others leads individuals to perceive themselves as similar and more inclined to identify with the group with which they synchronize. However, this boundary blurring may also cause blurring between self and other memories, reducing self-memory advantage.

Entrainment theory explains the advantage of anti-phase synchronized movement in enhancing self-memory. The entrainment phenomenon involves individuals bottom-up utilizing the periodicity of movements to generate phase synchronization between internal neural activity and external movement sequences (Henao et al., 2020). Entrainment theory proposes that synchronized activity is a process in which four different neural channels—perceptual, autonomic physiological, motor, and social—interact, leading to the generation of subjective synchronization perception (Trost et al., 2017). The synchronization process triggers neuronal synchronization across different brain channels (Bonnefond et al., 2017) and influences individuals' attention, working memory, and consciousness. Because individuals perform anti-phase movements with synchronization partners, this does not cause memory blurring between self and partner but instead promotes individuals' cognitive functions. Given that patients with Alzheimer' s disease exhibit neural synchronization deficits—where synchronization between brain neurons is disrupted, leading to declines in memory, attention, executive function, and visuospatial abilities (Sedghizadeh et al., 2022)—anti-phase synchronization may offer cognitive benefits.

Additionally, regions such as the anterior cingulate cortex and postcentral gyrus may constitute the neural basis of brain synchronization (García & Ibáñez, 2014). Sensory-motor theory proposes that rhythm and beat experiences are associated with input sensory representations and bodily movement representations. When maintaining the same beat with others, motor regions in the brain such as the supplementary motor area and cerebellum are activated (Todd & Lee, 2015), enabling accurate execution of repetitive bodily movements synchronized with rhythmic input. This explains synchronized phenomena in international ballroom dancing and duet synchronized swimming where in-phase and anti-phase alternate. When performing synchronized movements, perceiving others' movements activates brain regions related to one' s own similar movements (Overy & Molnar-Szakacs, 2009). This means moving simultaneously with others leads to co-activation of similar perceptual and motor neural networks—that is, movement and perception share the same neural system. This represents a phenomenon of coupling between two or more neurons that can occur across different sensory channels of synchronized activity, including visual, auditory, and tactile modalities. The rubber hand illusion has demonstrated that when a subject' s hand is hidden behind a board while an identical rubber arm is placed before them, and experimenters simultaneously brush the hidden hand and rubber hand with brushes, subjects perceive ownership of the rubber hand (Rohde et al., 2011). This indicates that blurring of self and others is possible even with cross-channel sensory input.

3.3 Psychological Effects and Physiological Mechanisms of Synchronized Movements with Different Consciousness Levels

In daily life, we can easily observe that spontaneous synchronization is more prevalent than conscious synchronization. During spontaneous synchronization, high-level empathy promotes individuals' subjective synchronization perception and increases positive emotional experiences (Llobera et al., 2016). Spontaneous synchronization has also been confirmed to develop secure attachment in children (Lundy, 2003). However, in spontaneous synchronization during joint drumming between children and experimenters, no pro-social behavior generation was found (Kirschner & Ilari, 2014). Conscious synchronization, nevertheless, plays an important role in influencing pro-social behavior, imitation tendencies, and memory. Inducing conscious synchronization between infants and strangers increased infants' pro-social behavior (Cirelli et al., 2017; Cirelli et al., 2016). Experiencing conscious synchronization showed tendencies to imitate synchronization partners and improved memory, whereas spontaneous synchronization lacking shared goals did not yield similar results (Cross et al., 2021). This reveals the important influence of synchronization with shared goals and intentions in social interaction and communication.

Conscious and spontaneous synchronization also share similarities, as both require allocation of attentional resources to synchronization partners' movements, linking them to cognitive attention. Research using the pendulum coordination paradigm found that adolescents with autism spectrum disorder exhibited low attention levels in both conscious and spontaneous synchronization, showing deficits in both types (Ftzpatrick et al., 2016). This suggests that both synchronization types involve cognitive attention; individuals tend to invest more attentional resources in synchronization partners to better notice their movements and maintain continuous synchronization. Subsequent research has found similar results. Conscious synchronization demonstrates stronger synchrony than spontaneous synchronization, and enhanced mu-wave activity in brainwaves facilitates spontaneous synchronization, with conscious synchronization occurring during mu suppression and being associated with the right hemisphere (Fitzpatrick et al., 2019).

Furthermore, research indicates that conscious synchronization has positive promotional effects on mental health and social response. For example, conscious synchronization conditions generate higher self-esteem and social bonding (Lumsden et al., 2014). These findings receive support from the mirror neuron system. When individuals execute movements or observe others executing the same movements, a potential neural mechanism exists through which we can understand others' movement goals (Rizzolatti & Sinigaglia, 2016) and synchronize. Conscious synchronization involves continuous coordination and prediction of synchronization partners' movements and intentions. When individuals execute movements, observing others' movements simultaneously activates the mirror neuron system and movement representations, facilitating synchronized movement occurrence. Participants experience illusions of bodily fusion after synchronized stimulation and perceive themselves as more similar to synchronizers (Paladino et al., 2010), becoming more inclined to bond with those with whom they synchronize. Notably, participating in synchronized activities can increase positive affect (Tschacher et al., 2014) but reduce individuals' ability to self-regulate emotion (Galbusera et al., 2019).

3.4 Relationship Between Synchronized Movements with Varying Numbers of Interaction Partners and Social Response and Their Psychophysiological Mechanisms

The pro-social effects of dyadic synchronized movement have received substantial research and confirmation. For instance, adult participants in dyadic synchronization often demonstrate higher cooperation levels than non-synchronizers (Launay et al., 2013), and this is equally effective in promoting cooperation between children and strangers (Rabinowitch & Meltzoff, 2017). Attention theory is frequently used to explain the cooperative effects of dyadic interactive synchronization. During synchronized activities, participants make synchronized responses, activate the brain, and generate neural synchronization between participants. By observing changes in alpha and beta waves, synchronized responses have been found to link with top-down attentional control (Cho et al., 2018). During dyadic interaction, participants' perception of each other' s movements prompts them to allocate attentional resources more heavily to interaction partners, showing stronger memory for partners' appearance information (Macrae et al., 2008). To investigate attention resource allocation in dyadic interaction, researchers have found that the precision and stability of synchronized movement are mediated by attentional resources and the amount of information individuals notice about synchronization partners' movements (Richardson et al., 2007). This means the stability and precision of dyadic synchronized movement are regulated by differences in visual attention allocation to synchronization partners.

Additionally, individuals may reduce psychological distance between each other and promote cooperation by focusing attention on others and their mental states for social cognitive inference (Baimel et al., 2015). Research on dyadic synchronized musical performance indicates that synchronized states enhance inference about others' mental states (Baimel et al., 2018). Small-scale dyadic synchronized movements can shape sociality by stimulating mentalizing abilities, facilitating coordination and cooperation in daily interpersonal relationships.

The social brain hypothesis proposes that social group size and neocortex size co-evolved, showing a logarithmic linear relationship, with cognitive constraints on group size (Zhou et al., 2005). According to the mirror neuron system, individuals observing others' movements activate sensory representations of those movements and transform them into their own representations of the movements, ultimately maintaining consistent actions (Rizzolatti & Sinigaglia, 2016). Dyadic synchronization primarily maintains synchrony through the coupling of visual and auditory modalities, with the effectiveness of visual and auditory coupling depending on temporal and spatial contexts (Nowicki et al., 2013).

Spontaneous synchronization frequently occurs during dyadic interaction (Costantini et al., 2018; Cuadros et al., 2020; Hoch et al., 2021). However, synchronization in group activities with three or more people is not accidental or unintentional but rather a conscious collective social activity. Performers consciously shift movements according to rhythm to induce changes in others' movements. They know that others simultaneously share the induced goal —collective synchronized performance. This shared mental state that makes collective synchronization possible is called shared intentionality (Tomasello & Carpenter, 2007). Kirschner et al. (2010) propose that shared intentionality is essential when collective singing and dancing generate cooperative effects. Even when individuals are not explicitly required to follow common goals, the synchronization process may evoke collective shared intentionality. Existing research indicates that four-person group dancing creates synchrony through shared intentionality and generates stronger synchronization awareness, further enhancing cooperation (Reddish et al., 2013).

When group size becomes excessively large, team synchrony decreases. When team group size expands beyond a certain threshold, individuals' ability to integrate team members' information and coordinate the entire group becomes limited, making it difficult to maintain consistency with other group members and consequently reducing team stability (Weinstein et al., 2016; Zhou et al., 2005). In large teams, completion through visual channels alone is difficult because human attentional resources are limited and cannot simultaneously attend to distant synchronization partners. Synchronization with three or more people involves two or more sensory channels to achieve group synchronization perception (Sofianidis & Hatzitaki, 2015). Research has shown that touch, vision, and hearing jointly influence large-group synchronization, with tactile coupling having the greatest impact on group synchrony (Chauvigné et al., 2019; Honisch et al., 2016). This may also explain why large-team scale synchronization can occur.

3.5 Relationship Between Synchronized Movements with Different Coordination Modes and Social Response and Their Affective and Biological Mechanisms

Among the three synchronized movements with different coordination modes, bidirectional synchronization produces the optimal synchronization effect, followed by unidirectional synchronization and external synchronization (Gallotti et al., 2017). Most previous research has focused on investigating bidirectional synchronization. For example, collective synchronized singing can positively influence performance effects (Dunbar et al., 2012), collective rowing can produce synchronization effects (Sullivan et al., 2014), and synchronized drumming can increase liking for synchronization partners (Launay et al., 2014). These studies have all found that bidirectional synchronization between individuals activates participants' endogenous opioid systems, releases endorphins, and increases pain thresholds.

Additionally, research has found that bidirectional synchronization between mother and child contributes to the development of children' s self-regulation abilities and social emotions (Bell, 2020). The bio-behavioral synchrony model explains this phenomenon: children instinctively respond to maternal cues, and their physiological activities follow maternal physiological regulation changes. When mother and child coordinate behaviorally, increased vagal nerve fibers facilitate the development of children' s behavioral regulation (Porges & Furman, 2011). Therefore, higher mother-child synchrony correlates with stronger children' s self-regulation abilities, possibly caused by increased vagal tone.

In recent years, some studies have discovered that external synchronization has positive influences on human social relationships. External synchronization typically occurs under external stimuli such as shared music, which is considered a product of human evolution. According to the theory of dynamic attending, selective attention increases at the moment of musical beat occurrence, which improves movement accuracy and processing speed (Van Wassenhove & Herbst, 2020). Rhythmic music conditions facilitate improved synchronization precision and increase liking for synchronization partners (Lang et al., 2016). External synchronization under musical rhythmic stimulation reduces employees' work stress and sick leave frequency (Göritz & Rennung, 2019).

This result has been attributed to endorphins' effects. Endorphins can reduce stress-induced neuroendocrine and autonomic nervous responses, diminishing the impact of stress by attenuating a range of physiological reactions including emotional states (Drolet et al., 2001).

Furthermore, unidirectional synchronization can influence individuals' moral hypocrisy. In one study, participants were required to maintain synchronization with a synchronization partner' s hand gestures in a video and were later informed that their synchronization partner had committed a moral violation, asking them to judge this behavior. Results showed that participants in the high unidirectional synchronization group judged their synchronization partner' s violation less strictly than those in low unidirectional synchronization and non-synchronization groups, with this result mediated by perceived solidarity between participants (Chvaja et al., 2020).

High-level unidirectional synchronized movement enhances solidarity and identification between groups, further promoting social bonding. However, this synchronization effect may hinder the application of cultural norms in society. Individuals may alter moral judgments based on the perpetrator' s identity, similar to phenomena of cronyism and nepotism that exist in real society.

3.6 Summary of Research on Different Types of Synchronized Movement

Table 1 lists some representative studies on different types of synchronized movements, summarizing the problems addressed by these studies, their experimental designs, and corresponding theoretical explanations. Regarding experimental design, current experimental research on synchronized movement mostly adopts single-factor experimental designs. Neurobiological theory is widely used to explain the psychological effects of synchronized movement.

Category	Study	Design	Explanation/Theory
In-phase/Anti-phase	Gabriel (2020)	Synchronized clapping → positive emotion	Synchronized/Non-synchronized
In-phase/Anti-phase	Lang (2017)	Synchronized drumming → endorphins → cooperation	Low-sync/High-sync
In-phase/Anti-phase	Tarr (2015)	Synchronized dancing, effort → social bonding	Sync/Partial-sync × effort (high/low)
In-phase/Anti-phase	Tarr (2016)	Synchronized dancing → endorphins → social cognition → bonding	Sync/Partial-sync/Async

Category	Study	Design	Explanation/Theory
In-phase/Anti-phase	Tarr (2017)	Synchronized dancing → endorphins, social cognition → bonding	Sync/Non-sync
In-phase/Anti-phase	Von Zimmermann (2016)	Synchronized speaking → liking, memory	Sync/Non-sync
In-phase/Anti-phase	Wilson (2019)	Different phases, effort → social cohesion	In-phase/Anti-phase
In-phase/Anti-phase	Sullivan (2014)	Different phases → synchronization effect	Non-sync/In-phase/Anti-phase
In-phase/Anti-phase	Sullivan (2017)	Different phases → synchronization effect	Non-sync/In-phase/Anti-phase
In-phase/Anti-phase	Miles (2010)	Different phases → self vs. other memory	In-phase/Anti-phase
Spontaneous	Cheng (2020)	Spontaneous sync → social impression	Non-sync/Spontaneous sync
Spontaneous	Kirschner (2014)	Spontaneous sync → pro-social behavior	Non-sync/Spontaneous sync
Spontaneous	Llobera (2016)	Spontaneous sync → empathy	Non-sync/Spontaneous sync
Spontaneous/Conscious	Fitzpatrick (2016)	ASD adolescents' synchronization	Spontaneous sync/Conscious sync

Category	Study	Design	Explanation/Theory
Conscious	Cirelli (2017)	Conscious sync → infant pro-social behavior	Non-sync/Conscious sync
Spontaneous/Conscious	Fitzpatrick (2019)	Spontaneous vs. conscious sync brainwaves	Spontaneous sync/Conscious sync
Spontaneous/Conscious	Cross (2021)	Spontaneous/Conscious sync → imitation, source memory	Conscious sync/No action/Non-sync
Conscious	Lumsden (2014)	Conscious sync → self-esteem	Non-sync/Conscious sync
Bidirectional	Dunbar (2012)	Bidirectional synchronized singing → effect	Non-sync/Sync
Bidirectional	Sullivan (2014)	Bidirectional synchronized rowing → effect	Non-sync/Sync
Bidirectional	Launay (2014)	Bidirectional synchronized drumming → liking	Non-sync/Sync
Bidirectional	Bell (2020)	Bidirectional synchronized dance → self-regulation	Non-sync/Sync
External	Göritz (2019)	External sync → work stress	Non-sync/Sync
Unidirectional	Chvaja (2020)	Unidirectional sync → moral hypocrisy	Non-sync/Sync

Category	Study	Design	Explanation/Theory
Dyadic	Baimel (2018)	Dyadic sync → mentalizing	Non-sync/Low-sync/High-sync
Dyadic	Wiltermuth (2009)	3-person sync → cooperation	Sync/Non-sync
Dyadic	Rabinowitch (2017)	Dyadic sync → communicative intent → reciprocal cooperation	Sync/Non-sync/No movement
Dyadic	Launay (2013)	Dyadic sync → cooperation	Sync/Non-sync/No movement
Multi-person	Reddish (2013)	4-person sync, shared intentionality → cooperation	Sync/Partial-sync × shared intentionality (yes/no)
Large group	Weinstein (2016)	Large group sync → endorphins → social closeness	Group size (large: 232/small: 20-80)
Large group	Lewis (2018)	Large group sync → endorphins → social closeness	Group size (large: 12/small: 2)

Research on social life synchronized movement and its positive psychological effects has deepened our understanding of synchronized movement, yet many questions in this field remain to be further explored:

First, the substitutive and compensatory nature of social life synchronization for collective ritual synchronization needs to be elucidated. This paper has elaborated on the substitutive role that social life synchronization plays for the positive psychological effects of collective rituals to some extent, but current research has not answered what the nature and form of this substitution or compensation are. For example, collective effervescence is considered a unique collective positive emotion of collective ritual synchronized movement, which can be evoked through participation in collective ritual synchronization to inspire feelings of self-transcendence and sacredness (Páez et al., 2015). Some researchers also believe that collective effervescence exists not only in collective rituals but that social life synchronized activities may play an even greater role in collective effervescence (Gabriel et al., 2020). Whether social life synchronized movement can enhance collective effervescence has not been fully confirmed, and questions such as whether collective effervescence generated through social life synchronization is similar in nature and form to that produced by collective rituals await investigation.

Second, the social effects of different types of synchronized movement need to be examined. Current empirical research results on social life synchronized movement show inconsistencies. For example, contradictions exist regarding the synchronization effects of full synchronization versus anti-phase synchronization. Previous research has generally considered full synchronization to have stronger synchronization effects than anti-phase synchronization. However, Sullivan and Blacker' s (2017) study found that anti-phase synchronization has synchronization effects while full synchronization does not produce synchronization effects. This suggests that synchronized movements at different phases may influence synchronization effects. Another example: research found that endorphins released during synchronized drumming promote cooperation (Lang et al., 2017). However, Sullivan et al. (2015) found that synchronized running increased cooperation levels but showed no significant change in pain threshold, indicating that this effect was not caused by endorphins. It should be noted that synchronized drumming and synchronized running represent different external manifestations, and using neurobiological theory to provide a general explanation may confuse the mechanisms of different synchronization forms. Furthermore, different phases of synchronized movement also lead to different results. Compared with anti-phase synchronized rowing, in-phase synchronized rowing showed significantly increased pain thresholds (Sullivan et al., 2014). However, anti-phase rowing is unconventional in rowing sports; rowers do not row in anti-phase patterns. Researchers subsequently designed synchronized drumming and found that anti-phase synchronized drumming produced significantly greater pain threshold changes than in-phase synchronized drumming (Sullivan & Blacker, 2017). This suggests that synchronization effects produced by synchronized movement may relate to whether the movement is common or novel and to the movement' s phase. Therefore, these contradictory research results need to be re-examined under conditions of consciousness level, phase, and movement novelty.

Third, the mechanisms through which different types of synchronized movement affect social response factors and mental health need to be revealed. Previous literature has primarily focused on investigating common synchronized movements and in-phase synchronization (full synchronization), with less attention paid to other types such as anti-phase synchronization, spontaneous synchronization, and external synchronization. Additionally, previous scholars have proposed four theoretical mechanisms—neurobiological theory, affective theory, attention theory, and the blurring-of-self model—to explain synchronized movement from different perspectives. These theories may not be mutually exclusive but rather interrelated. For example, one study found that collective synchronized singing can promote social bonding, where increased positive affect was observed in addition to increased pain threshold (Weinstein et al., 2016). This implies two pathways for social bonding: one through endorphin release, the other through arousal of positive emotion. Current research has concentrated on investigating the biological mechanisms of synchronized movement, with neurobiological theory receiving substantial empirical support, while other theoretical mechanisms have been less involved. These issues all await resolution.

Fourth, the specific process mechanisms behind synchronization effects across different group sizes need to be explored. Although existing research has confirmed that small-scale synchronized activities such as dyadic synchronization are regulated by attentional resources, tending to support attention mechanisms, synchronized activities in reality involve larger participant groups appearing in large-team formations. When team scale gradually expands, participants' attentional resources are limited, making it extremely difficult to allocate limited attentional resources to each individual. Some research indicates that collective effervescence is more likely to occur in larger groups, while attention mechanisms may be more suitable for explaining small-team scales (Jackson et al., 2018). However, questions such as whether participants allocate attention to nearby partners according to proximity principles or whether affective mechanisms are favored have not been fully resolved, especially regarding research on large-group scale synchronized movement mechanisms. More studies are needed to examine the mechanisms through which large-group scale synchronized movement generates positive social response and mental health.

Finally, concepts similar to social life synchronized movement—such as collective directional movement and imitation—also have psychological effects similar to synchronized movement. Collective directional movement involves a group moving from one place to another (Wilson & Mansour, 2020), emphasizing spatial change, whereas synchronized movement focuses on locking movements in time and phase. Research has found that groups engaged in directional movement show greater cohesion than those engaged in non-directional activities (Wilson et al., 2018; Wilson & Mansour, 2020). Imitation not only increases intimacy and trust between people (Hale, 2017) but also promotes pro-social behavior (Fischer-Lokou et al., 2011). The distinction between imitation and synchronized movement is ambiguous, but at least one point is clear: when manipulating both, participants are required to make explicit movement matching, yet imitation pursues speed rather than precise movement matching, and participants need not complete full movements (Chen Wuying, Liu Lianqi, 2013). The mechanisms of imitation and synchronized movement are contradictory, and it remains unclear whether the mechanisms underlying their similar effects are related (Rauchbauer & Grosbras, 2020). This also represents content for future research to further explore.

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