

I understand the task is to translate a Chinese academic paper title to English, but the actual Chinese title text is missing from your prompt. The “TEXT TO RETRANSLATE” section only contains meta-commentary about the translation task itself, not the original Chinese title. To complete this trans...

Authors: The user has provided a single Chinese character “薛秋”. This appears to be a name, likely a person’s name. The character “薛” (Xuē) is a Chinese surname, and “秋” (Qiū) means “autumn” but is commonly used as a given name.

Given the context of the instructions about translating academic papers with LaTeX commands, math placeholders, and tags, this seems like a test or a fragment. The user might be testing if I can handle a simple input correctly.

The instructions are very specific: 1. Preserve ALL LaTeX commands and placeholders exactly 2. Preserve ALL citation commands 3. **PRESERVE ALL ...paragraph wrapper tags EXACTLY** 4. Maintain academic tone and formal scientific writing style 5. Use precise technical terminology - obey the glossary strictly 6. Preserve section structure and paragraph organization 7. Translate all content completely - do not omit any information

OUTPUT RULES: - Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent). - Keep one output paragraph per input paragraph; do not merge or split paragraphs. - **Maintain exact count and IDs of ...tags** - if input has N paragraph tags, output must have exactly N paragraph tags with matching IDs - Do NOT add Markdown formatting unless it is present in the source. - Preserve original line breaks within the paragraph when meaningful; otherwise use standard English sentence spacing.

The input is just “薛秋” with no tags, no LaTeX, no citations. This is a very simple case. I should translate it as a name. In academic contexts, Chinese names are typically transliterated using Pinyin. “薛秋” would be “Xue Qiu” .

However, I need to consider the format. The input is just plain text. The instructions say to preserve tags if they exist. Since there are none, I should just return

the translation. But I need to be careful about the OUTPUT RULES which say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).”

So I should just output “Xue Qiu” without any additional formatting or explanation.

Wait, let me re-read the instructions more carefully. The user is asking me to translate from Simplified Chinese to English, The user has provided a very short input: “尹可丽”. This appears to be a Chinese name. Let me analyze what needs to be done:

1. The instruction says to translate from Simplified Chinese to English with academic tone
2. The critical requirements mention preserving LaTeX commands, citation commands, and tags
3. The output rules say to return ONLY the translated text
4. The glossary provides translations for technical terms but doesn't cover names

The input “尹可丽” is a Chinese name. In academic translation, Chinese names are typically transliterated (Pinyin) rather than translated semantically. “尹可丽” would be “Yin Keli” in Pinyin.

However, I need to check if this is part of a larger context. The user only provided this single name. The instructions are very specific about preserving tags, but there are none in this input. There are no LaTeX commands, no citations, no mathematical formulas.

Given the strict requirements, I should consider: - Is this a test to see if I follow instructions precisely? - Should I just return the transliterated name? - Should I wrap it in some structure?

The instructions say “Translate from Simplified Chinese to English” and “Return ONLY the translated text”. Since this is a name, the standard academic practice is to transliterate it. “尹可丽” becomes “Yin Keli” .

But wait - the instructions are extremely specific about preserving tags. The user might have intended to provide a full paragraph but only gave a name. Or this might be a fragment of a larger text.

Let me re-read the instructions carefully: - “PRESERVE ALL …paragraph wrapper tags EXACTLY” - “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).” - “Keep one output paragraph per input paragraph; do not merge or split paragraphs.” - “Maintain exact count and IDs of …tags”

The input has NO tags. So according to the rules, I should not add any. I should just translate what's given.

The name “尹可丽” is three characters: - 尹 (Yǐn) - a surname - 可 (Kě) - a given name character - 丽 (Lì) - a given name character

Standard transl, The user has provided a very short input: “尹可丽”. This appears to be a Chinese name. Let me analyze the requirements:

1. The user wants me to translate from Simplified Chinese to English with highest accuracy and academic tone
2. I must preserve ALL LaTeX commands and placeholders
3. I must preserve ALL citation commands
4. **PRESERVE ALL \cdots paragraph wrapper tags EXACTLY**
5. Maintain academic tone and formal scientific writing style
6. Use precise technical terminology from the glossary
7. Preserve section structure and paragraph organization
8. Translate all content completely

However, the input “尹可丽” is just a name. It’ s not wrapped in any tags, doesn’ t contain any LaTeX, citations, or mathematical formulas. It’ s also not a paragraph of academic text.

The glossary provided only contains: - 机器学习 => machine learning - 深度学习 => deep learning

“尹可丽” is a personal name, which doesn’ t appear in the glossary. In academic translation, Chinese names are typically transliterated using standard pinyin systems. “尹可丽” would be “Yin Keli” in pinyin.

But wait - I need to check if there are any special requirements. The user has given me very specific formatting rules about preserving tags, but the input doesn’ t have any. The instructions say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).”

Since the input is just a name without any tags, I should just provide the transliteration. However, I should also consider: is this a test to see if I follow the rules even when the input is minimal? The rules say: - “Keep one output paragraph per input paragraph; do not merge or split paragraphs.” - “**Maintain exact count and IDs of \cdots tags** - if input has N paragraph tags, output must have exactly N paragraph tags with matching IDs”

Since the input has 0 paragraph tags, the output should have 0 paragraph tags. So I should just output the transliterated name.

But let me double-check: is “尹可丽” possibly a technical term? No, it’ s clearly a personal name. Could it be a brand name or specific term? Unlikely given the context of academic paper translation.

The most appropriate translation/transliteration would be “Yin

Date: 2024-09-08T00:00:00+00:00

Abstract

As a core element of collective rituals and a component of social life, the impact of synchronous actions on social bonding and its underlying mechanisms remain unclear. Based on emotion theory and Durkheim's perspective, this paper proposes that synchronous actions can promote social bonding, collective effervescence serves as the mediating mechanism through which synchronous actions enhance social bonding, and the effect of this mechanism is related to group size. Three experiments employing a silent disco paradigm examined the effects of synchronous actions, collective effervescence, and team size on social bonding. Experiment 1 demonstrated that synchronous actions (vs. no action) produced stronger social bonding effects, with collective effervescence playing a mediating role. Experiments 2 and 3 were conducted among high school students and construction workers, respectively. The results indicated that synchronous actions enhanced social bonding, and that collective effervescence was higher in large team sizes, thereby generating stronger social bonding. This paper reveals that synchronous actions promote and sustain social bonding among large groups of strangers through the mechanism of collective effervescence, which holds significant implications for group survival and social development.

Full Text

The Influence of Synchronized Movement on Social Bonding: The Mediating Role of Collective Effervescence and the Moderating Role of Group Size

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Abstract

As a core element of collective rituals and an integral component of social life, the influence of synchronized movement on social bonding and its underlying mechanisms remain unclear. Grounded in affective theory and Durkheim's perspective, this paper proposes that synchronized movement can promote social bonding, with collective effervescence serving as the mediating mechanism, and that this mechanism's effect is related to group size. Three experiments employed the silent disco paradigm to examine the effects of synchronized movement, collective effervescence, and group size on social bonding. Experiment 1 demonstrated that synchronized movement (vs. no movement) produced stronger social bonding effects, with collective effervescence playing a mediating role. Experiments 2 and 3 were conducted among high school students and construction workers, respectively. Results showed that synchronized movement enhanced social

bonding, with higher levels of collective effervescence in large group sizes, which in turn produced stronger social bonding. This study reveals how synchronized movement promotes and maintains social bonding among large groups of strangers through the mechanism of collective effervescence, holding important implications for group survival and social development.

Keywords: synchronized movement, collective effervescence, group size, social bonding

Introduction

As the saying goes, “A single thread cannot make a cord, nor a single tree a forest.” Humans are inherently social creatures who desire to establish and maintain relationships with others. Possessing stable social bonds can improve mental health (Emerson et al., 2021; Tunçgenç et al., 2023) and reduce depression, suicide, and immune dysfunction (Charles et al., 2020; Lutz et al., 2020). Throughout human evolution, humans have faced the challenge of establishing and maintaining social bonds in gradually expanding groups, yet the mechanisms for maintaining social bonds in large social groups remain poorly understood (Weinstein et al., 2016). Among primates, social bonds are established through one-on-one physical grooming, which promotes intimate emotions between individuals. However, considering that humans live in much larger groups than primates, developing social bonds is constrained by time limitations. People need to find more effective methods to simultaneously establish social intimacy with multiple individuals, not limited to one-on-one interactions (Dunbar, 2020). Synchronized movement is crucial for large-scale social groups to maintain social relations and is significant for group survival and social development. Therefore, investigating the relationship between synchronized movement and social bonding and its underlying mechanisms holds important theoretical and practical significance.

Currently, research on the influences of social bonding has primarily focused on examining music’s impact and its mechanisms. For example, choral singing can enhance social bonding (Weinstein et al., 2016); synchronized dancing can promote social bonding (Tarr et al., 2015); and synchronized dancing can increase social intimacy by releasing endorphins (Tarr et al., 2017). Although previous studies have manipulated participants through choral/non-synchronous singing/no singing, synchronized/asynchronous dancing, etc., these manipulations confound the effects of music and physiological synchrony on social bonding, making it impossible to determine whether music or synchronized movement plays the key role in promoting social bonding. Recently, some researchers have proposed that synchrony may be the key component of joint musical activities (Li et al., 2024), and that synchronized movement constitutes the foundation of social bonding (von Zimmermann & Richardson, 2016). Therefore, it is necessary to examine whether synchronized movement alone promotes social bonding.

Previous research has primarily focused on synchronized movement in small groups, especially the effects of dyadic synchrony on social responses (Xue & Yin, 2023). For instance, dyadic synchrony can enhance mentalizing (Baimel et al., 2018), promote cooperation between children and strangers (Rabinowitch & Meltzoff, 2017), improve social impressions (Cheng et al., 2020), and enhance moral hypocrisy (Chvaja et al., 2020). However, synchronized movement in real social life involves larger groups, typically appearing in large-scale formations, not limited to small groups like dyadic synchrony. Examples include broadcast calisthenics on school playgrounds, square dancing in parks, and military training before school terms. When group size continuously expands, can synchronized movement promote social bonding on a large scale? Will its social bonding effect still work? What are the internal mechanisms? Existing research struggles to provide insightful answers.

Few studies have examined the effects of large-group synchronized movement, finding that large-group synchronized rowing increases individuals' pain thresholds, suggesting that the synchrony effect in large groups is more durable (Lewis & Sullivan, 2018). However, the existing literature has not explained how group size moderates the social bonding effect of synchronized movement or how group size moderates the influence of synchronized movement on social bonding through collective effervescence.

Affective theory proposes that the positive social outcomes of synchronized movement are based on the role of collective effervescence, which is more easily aroused in large-scale group environments (Jackson et al., 2018). Synchrony affects people's emotions, and synchronized activities change individuals' emotional experiences, arousing collective effervescence and thereby increasing prosocial behavior (Mogan et al., 2017). Therefore, based on affective theory, this study explores the influence of synchronized movement on social bonding through three experiments. Experiment 1 verifies the main effect of synchronized movement and the mediating role of collective effervescence. Experiment 2 aims to further verify the moderating role of group size in the aforementioned relationship. Experiment 3 selects adult participants to replicate the results of Experiment 2, thereby improving the external validity and robustness of the research conclusions.

1.1 Synchronized Movement and Its Research Paradigm

Synchronized movement refers to the matching tendency in behavior among individuals at the same time and/or with the same periodicity (Jackson et al., 2018; Reddish et al., 2014). Synchronized movement originated from collective rituals and represents one of the core psychological elements of collective rituals, being a recurring feature in collective rituals worldwide, such as synchronized mourning, synchronized chanting, and collective prayer. Previous research has categorized rituals into individual and collective rituals based on the num-

ber of people, with synchronized movement extracted as the characteristic that distinguishes collective rituals from individual rituals. However, synchronized movement exists not only in collective rituals but also commonly in non-ritual contexts—secular daily social life situations. For example, synchronized speech, synchronized exercise, and walking side by side in step are common phenomena in social life. Therefore, synchronized movement is also regarded as a universal feature of social life and a fundamental component of human social existence (Marsh et al., 2009). Secular synchronized movement can improve inference of others' mental states (Baimel et al., 2018), reduce work stress (Görizt & Renning, 2019), enhance memory (Cross et al., 2021), and promote more prosocial behavior in children as they mature (Cirelli, 2018).

Previous studies on synchronized movement have employed experimental methods, typically asking participants to perform synchronized movements accompanied by familiar music. However, synchronized movement may be constrained by music familiarity, making it difficult to reveal causal relationships in dynamic group environments accompanied by music or rhythm (Fink et al., 2021). Yet, without music or external rhythm, the precision of synchronized movement is difficult to control. To address this issue, researchers have proposed the “silent disco paradigm,” which provides rigorous manipulation of synchronized movement and has received consistent validation in current research as an effective method for studying physiological and psychological changes related to synchronized movement. The “silent” aspect of the silent disco paradigm means that the experiment does not use a unified external sound/music beat. Instead, each participant wears headphones and performs pre-practiced actions according to their individual headphone rhythm. Participants do not know whether the rhythms in their headphones are the same, as the audio information may be identical or different, thereby placing participants in synchronized or non-synchronized states. The musical rhythm in this paradigm aims to control whether movements are synchronized through different headphones. Therefore, any effects on dependent variables during the synchronization process can be attributed to synchronized movement itself (Fink et al., 2021; Tarr et al., 2016).

1.2 The Influence of Synchronized Movement on Social Bonding

Social bonding represents a form of positive social interaction that plays a decisive role in the ecological environments of animals, including humans (Carter & Keverne, 2017). Social bonding requires time to develop, and group membership becomes a core component of individual identity, with individual and group identities firmly “fused” together (Swann et al., 2012). Social bonding develops based on frequent and sustained affiliative interactions, with trust, similarity, belonging, and social cohesion considered effective measures of social bonding (Gächter et al., 2015; Launay et al., 2013). Characteristics of strong social bonding typically include a sense of belonging, trust, commitment, and willingness to engage in altruistic behavior that sacrifices self-interest for others' benefit (Hen-

rich & Muthukrishna, 2021; Whitehouse, 2018). In recent years, social bonding has been widely applied in mental health and counseling psychology as a psychological construct that better describes individuals' experiences of self-other relationships.

The music-social bonding hypothesis suggests that music can function as a mechanism to promote and maintain social bonding among group members during human evolution (Savage et al., 2021). For example, synchronized dancing and exertion can promote social bonding (Tarr et al., 2015), and synchronized dancing can increase social intimacy by activating the endogenous opioid system to release endorphins (Tarr et al., 2017). Similarly, research examining singing's effect on cooperative behavior found that participants' cooperative behavior increased significantly after choral singing compared to non-singing and non-synchronous singing conditions (Wiltermuth & Heath, 2009). Weinstein et al. (2016) also found that choral singing can increase social intimacy through endorphins. Previous research based on the music-social bonding hypothesis (Li et al., 2024; Savage et al., 2021) has focused on music's influence on social bonding. Whether choral singing or synchronized dancing, these activities involve physiological synchrony across tactile, auditory, and motor domains, confounding the joint promotional effect of music and synchrony on social bonding. However, synchronized movement as an adaptive social behavior is considered fundamental to social bonding (von Zimmermann & Richardson, 2016). Li et al. (2024) also proposed that synchrony may be the key component of joint musical activities, with synchronized activities more likely to promote prosocial behavioral tendencies than asynchronous activities. Therefore, we speculate that the essence of music's influence on social bonding lies in synchronized movement, which can still promote social bonding even without a musical context. This study manipulates synchronized movement in a manner that does not involve music and examines its influence on social bonding. Based on the above, we propose the following hypothesis:

H1: Compared with non-synchronized movement, synchronized movement has a promoting effect on social bonding.

1.3 The Mediating Role of Collective Effervescence

Collective effervescence refers to a positive emotional experience when individuals jointly participate in synchronized activities with others (Durkheim, 1912). It is consistently regarded as a psychological experience associated with intense emotion and happiness, viewed as a collective positive emotion. It is not a rare mystical event but rather an important component of daily social life (Gabriel et al., 2020). Researchers have operationalized collective effervescence as individuals' perception of sharing an emotional experience with others (Włodarczyk et al., 2020). Collective effervescence experiences are often associated with positive emotional outcomes, such as life satisfaction, awe, self-esteem, and social

intimacy. Research on collective effervescence has found that conscious synchronized movement among participants is one of the necessary conditions for collective effervescence to occur (Włodarczyk et al., 2020). Affective theory suggests that the emotional effects of synchronized movement are based on collective effervescence. When people gather together and highly synchronize their movements, the group is perceived as cohesive because closely coordinated movements suggest positive emotions to perceivers (Marsh et al., 2009). The hive hypothesis also supports that participating in synchronized activities easily triggers collective effervescence, as individuals experience happiness when integrated into a collective, possibly deriving intense pleasure from hive-like activities (Haidt et al., 2008).

According to Durkheim's perspective, during collective religious rituals, co-presence and interaction cause individuals to cognitively shift from self-awareness to group awareness. The synchronization of gestures and movements among group members strengthens emotional communication, thereby triggering collective effervescence (Durkheim, 1912). Collective effervescence is considered a unique collective positive emotion arising from synchronized movement in collective religious rituals, with participation in collective ritual synchronization capable of arousing collective effervescence and evoking a sense of sacredness (Páez et al., 2015). That is, synchronized movement in collective rituals easily awakens collective effervescence. Additionally, participation in secular ritual synchronized activities can also generate collective effervescence, making individuals feel life is more meaningful (Charles et al., 2021). Recent research suggests that in the absence of collective rituals, social life synchronization has certain substitutive and compensatory effects for collective ritual synchronization (Xue & Yin, 2023). Some researchers also believe that collective effervescence exists not only in collective rituals but that social life synchronized activities may have an even greater effect (Gabriel et al., 2020). Whether social life synchronized movement can enhance collective effervescence has not been fully confirmed. Based on the above, this paper argues that during synchronized movement, participants easily awaken collective effervescence through their perception of coordinated movements with each other. We therefore propose the following hypothesis:

H2: Compared with non-synchronized movement, synchronized movement enhances collective effervescence levels.

When individuals experience collective effervescence, it helps establish stable social relationships (Durkheim, 1912). Collective effervescence is an important predictor of interpersonal interaction, facilitating individuals' connection with groups (Gabriel et al., 2017). As an internal emotional response, collective effervescence as a collective positive emotional experience is easily transferable, with individuals more likely to associate this exciting experience with those gathered together, thereby triggering shared emotions among people (Rimé, 2009). This means that synchronized emotional responses promote close connections between individuals and the co-present group, thereby strengthening social co-

hesion (Carter & Keverne, 2017). Additionally, the neo-Durkheimian model of collective processes emphasizes that participants' experience of multi-faceted synchrony promotes perceived emotional synchrony (i.e., collective effervescence), which in turn produces positive effects such as social identity and cohesion (Páez et al., 2015; Włodarczyk et al., 2023). High emotional arousal levels of collective effervescence reduce individualism and blur the boundaries between self and others, promoting fusion between individual self and others (Carter & Keverne, 2017). The fusion of identity between individual and collective or the blurring of self-other boundaries prompts individuals to direct their personal agency toward group behavior, thereby stimulating self-sacrificial pro-group behavior (Swann et al., 2012). Research shows that when individuals experience high arousal levels of collective effervescence, their social cohesion with the entire group also strengthens (Zumeta et al., 2020); positive emotional experiences can enhance intimacy among members, thereby promoting social bonding (Juslin, 2021; Weinstein et al., 2016). Thus, we believe that when individuals are in a high emotional arousal state of collective effervescence, it can enhance social bonding between them and others. We propose the following hypothesis:

H3: Collective effervescence influences social bonding. The higher the collective effervescence, the higher the level of social bonding.

Integrating hypotheses H1, H2, and H3, we propose that compared with non-synchronized movement, synchronized movement conditions more easily enhance individuals' experience of collective effervescence, trigger shared emotions among groups, reduce the salience of personal self and blur boundaries with others, and further promote social bonding among synchronized members. We therefore propose the following hypothesis:

H4: Collective effervescence mediates the influence of synchronized movement on social bonding.

1.4 The Moderating Role of Group Size

Regarding the classification of group size, the sports domain defines 2 people as a small team and teams exceeding 12 people as large teams, a classification considered generally reasonable (Moreland et al., 2018). Based on previous literature on synchronized movement that has focused on group sizes of 2–6 people (Baimel et al., 2018; Galbusera et al., 2019; Launay et al., 2014; Rabinowitch & Meltzoff, 2017), this study refers to 4-person teams as small group size and 16-person teams as large group size.

Previous research on synchronized movement has often been conducted in small group sizes (Baimel et al., 2018; Rabinowitch & Meltzoff, 2017; Tarr et al., 2018; Wiltermuth & Heath, 2009), particularly dyadic synchrony. However, in real social environments, collective synchronized activities typically appear in group formations, such as group dancing, military training, and collective

singing. That is, synchronized movement in real life involves larger group sizes, not limited to dyadic small groups. Synchronized movement has been shown to not only increase interpersonal interaction and stimulate positive social behavior but also promote higher levels of solidarity, indicating that synchronized movement is related to establishing and maintaining large-scale social bonding (Pearce et al., 2016). Research examining the processes underlying synchrony effects across different group sizes found that both 12-person large groups and 2-person small groups showed increased pain thresholds, but after 10 minutes of movement, the large group's pain threshold was significantly higher than the small group's (Lewis & Sullivan, 2018). Both large and small groups activate the endogenous opioid system after synchronized movement, leading to increased pain thresholds (Launay et al., 2016; Tarr et al., 2016), consistent with neurobiological theory assumptions. These results also tend to support an affective mechanism, as group members in large-scale contexts easily share emotions, and large-group synchronized behavior utilizes emotional resources to function in social bonding, making the synchrony effect in large groups more durable in experiments. This suggests that large groups produce more persistent synchrony effects, and it is speculated that collective effervescence is more easily aroused in large-group contexts.

The phenomenon of collective effervescence may be more pronounced in large groups than in small groups, and large-scale group synchronized movement may easily trigger emotions to produce positive effects regardless of whether synchrony is tightly coupled (Mogan et al., 2017). Some scholars believe that when people integrate into a collective, they experience strong happiness because individuals more easily experience high levels of collective positive emotions from hive-like activities (Haidt et al., 2008). Compared with dyadic synchrony in small groups, collective effervescence may tend to occur in larger group sizes (Jackson et al., 2018). That is, large-group collective activities tend to support affective theory. Therefore, this paper proposes the following hypothesis:

H5: Group size moderates the influence of synchronized movement on collective effervescence. Compared with small group size, synchronized movement groups in large group size conditions exhibit higher levels of collective effervescence.

Combining H4 and H5, we argue that group size moderates the effect of synchronized movement on social bonding through collective effervescence. That is, as group size continuously expands, the mediating role of collective effervescence in the influence of synchronized movement on social bonding strengthens. We therefore propose the following hypothesis:

H6: Group size moderates the mediated effect of synchronized movement on social bonding through collective effervescence.

Based on the above, we established the overall research framework, as shown in Figure 1 [Figure 1: see original paper].

Experiment 1

Experiment 1 aimed to employ the silent disco paradigm to examine the influence of synchronized movement on social bonding and the mediating role of collective effervescence. Data and research materials are publicly available at <https://www.scidb.cn/s/V7jErq>.

2.1.1 Participants

Using G*Power 3.1.9.2, with an expected medium effect size of $f = 0.25$, $\alpha = 0.05$, and statistical power of $1 - \beta = 0.80$, the results indicated that 128 participants were needed. This study recruited 132 high school students. One group was excluded because participants reported being close friends, resulting in a final sample of 128 valid participants, including 69 males and 59 females. The mean age of participants was 16.74 ± 2.15 years.

2.1.2 Experimental Design

This experiment used a single-factor two-level (synchronized movement vs. complete no-movement) between-subjects design. The independent variable was synchronized movement, the mediating variable was collective effervescence, and the dependent variable was social bonding.

2.1.3 Materials and Measures

Synchronized Movement: In previous research, synchronized movement refers to the matching tendency in behavior among individuals at the same time and/or with the same periodicity (Jackson et al., 2018; Reddish et al., 2014), emphasizing the degree of consistency in behavior in terms of form and timing. Therefore, this study designed a simple table-tapping dance based on Baimel et al.'s (2018) operationalization of synchronized movement. Specifically: Participants sat face-to-face at a table and listened through individual headphones to a musical rhythm with three beats per measure. One movement was performed per beat, with participants executing three consecutive movements in each musical measure. The specific movements for the first measure were: Movement 1—place both hands at chest level, shoulder-width apart, palms down, tap the table once, then return to the original position; Movement 2—repeat Movement 1; Movement 3—keep hands at chest level, palms facing each other, and clap. A complete set consisted of 5 measures, with each measure's movements repeated four times consecutively. The first two beats of each measure were identical, with only the third beat differing. The third-beat movements for Measures 2–5 were: hands with fingers spread and palms forward; hands giving thumbs-up facing forward; hands raised above head with palms facing each other; hands parallel to left/right side with palms down. These movements were recorded as a 4-minute video presented to participants for learning.

Manipulation Check: After completing the synchronized movement task, participants underwent an operational effectiveness test. To verify whether the

movement manipulation was effective, participants' synchrony perception was measured using Reddish et al.'s (2013) 4-item scale: "I felt coordinated with other participants," "I felt other participants' opinions were consistent with mine," "I felt disconnected from other participants," and "I felt out of sync with other participants" (the latter two items were reverse-scored). All items used a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree). In Study 1, the internal consistency coefficient was 0.89.

Collective Effervescence: We used Gabriel et al.'s (2020) 8-item scale, revised as follows: (1) I felt integrated with members participating in this activity; (2) I felt most participants had the same emotional experience; (3) I felt most participants felt integrated with other participants; (4) I felt this activity seemed to have a larger purpose; (5) I felt this activity seemed to have something sacred; (6) I felt this activity seemed somewhat special; (7) I felt this activity changed me in some way; (8) This activity made me feel closer to the participants present. Items were rated on a 7-point scale. Higher total scores indicated higher collective effervescence levels. In Study 1, the internal consistency coefficient was 0.90.

Social Bonding: We used Wolf et al.'s (2016) 8-item scale, revised as follows: (1) How much did you like the other participants? (2) To what extent do you think the other participants were liked by others? (3) How positive were your impressions of the other participants? (4) How much did you trust the other participants? (5) How connected did you feel to the other participants? (6) If you had to do a similar task again, how would you feel about doing it with this specific participant again? (7) How much cooperative willingness did you have toward the participant sitting next to you? Items were rated on a 7-point scale. The final item was from the Inclusion of Other in the Self Scale (IOS Scale) (Aron et al., 1992), which measures individual-group relationships. This item includes 7 pairs of circles with linearly increasing overlap, forming a 7-point interval scale. The instruction reads: "Please circle the pair of circles below that best represents your relationship with the team you just completed the activity with." The 7 pairs of circles are labeled A-G, corresponding to scores of A = 1, B = 2, C = 3, D = 4, E = 5, F = 6, G = 7. Scores across these items were averaged to obtain the total social bonding score, with higher scores indicating greater social bonding. In Study 1, the internal consistency coefficient was 0.91.

Control Variable: Following previous research (Reddish et al., 2013), this study controlled for familiarity among team members. One item, "Please rate your familiarity with the other participants in your group," was used to measure the familiarity of participants randomly assigned to a group, ensuring that participants in each group did not know each other to rule out potential alternative explanations (Bernerth & Aguinis, 2016).

2.1.4 Procedure

First, participants ($N = 128$) were randomly assigned to either the synchronized movement group or the complete no-movement group, with 64 participants in each group. Within each group, participants performed synchronized movement tasks in teams of 4. Subsequently, one item measuring familiarity among group members was administered to ensure participants did not know each other.

Second, the experimenter informed participants: “You will participate in a team performance task. In this task, you will perform a table-tapping dance in a specific manner accompanied by a rhythmic sound.” Participants in a team sat together at a table, and the experimenter explained that they would hear a rhythm with three beats per measure through individual headphones. Therefore, they would execute three consecutive movements in each musical measure—one movement per beat. The experimenter then played a demonstration video of the table-tapping dance for participants.

Third, after watching the video, participants practiced the movements on their own without the sound rhythm. During this period, the experimenter corrected any movement errors. After all participants indicated familiarity with the movements, they practiced at least twice to verify they had learned and were familiar with the correct movements. The experimenter then informed participants: “Next, each of you will hear a 4-minute sound rhythm through individual headphones. During these 4 minutes, please focus on the sound beat you are hearing to execute the movements. Please note that you may hear a different version of the sound beat than other participants. Therefore, please pay special attention to the sound beat you hear through your headphones.” Participants then listened to the rhythm once without executing movements, after which they were reminded: “Please focus on the sound beat you hear through your headphones and begin executing movements when the sound beat starts.”

Finally, in the synchronized condition, all participants’ headphones in a group were connected to a single MP3 player, and they heard the same 128 BPM (beats per minute) sound beat. The MP3 player and wires were hidden in a cardboard box to prevent participants from knowing whether they were all connected to the same MP3 player. In the complete no-movement condition, participants did not execute any movements and were allowed to rest for a few minutes before completing the questionnaire. After participants completed the synchronized movement task, the experimenter told all participants they had performed well and distributed questionnaires containing the synchrony effectiveness manipulation check, collective effervescence, social bonding, and demographic variables. After participants completed the questionnaires, the experimenter explained the study’ s purpose and expressed gratitude.

2.2.1 Familiarity Check

Across all groups, 71.2% of participants did not know each other. Therefore, the potential influence of pre-experimental familiarity among participants on

the results could be ruled out.

2.2.2 Synchronized Movement Manipulation Check

An independent samples *t*-test was conducted to verify the effectiveness of the synchronized movement manipulation. Results showed a significant difference between the two groups in scores on the synchrony perception items, with the synchronized movement group ($M_{\text{synchronized}} = 5.67$, $SD = 0.73$) scoring significantly higher than the no-movement group ($M_{\text{no-movement}} = 2.68$, $SD = 0.93$; $t(126) = 20.14$, $p < 0.001$, Cohen's $d = 3.58$). This indicates that the designed movement materials effectively manipulated participants' synchronized movement.

2.2.3 Participants' Collective Effervescence and Social Bonding

Independent samples *t*-test results revealed significant differences between the two groups in collective effervescence scores. The synchronized movement group ($M_{\text{synchronized}} = 4.89$, $SD = 0.62$) scored significantly higher than the no-movement group ($M_{\text{synchronized}} = 3.23$, $SD = 0.61$; $t(126) = 15.20$, $p < 0.001$, Cohen's $d = 2.70$). Significant differences also emerged in social bonding scores, with the synchronized movement group ($M_{\text{synchronized}} = 5.01$, $SD = 0.55$) scoring significantly higher than the no-movement group ($M_{\text{synchronized}} = 3.32$, $SD = 0.65$; $t(126) = 15.92$, $p < 0.001$, Cohen's $d = 0.81$), supporting H1. These results indicate that synchronized movement enhanced both collective effervescence and social bonding.

2.2.4 The Mediating Role of Collective Effervescence

Following Preacher and Hayes' s (2008) PROCESS macro, we used Model 4 with the bootstrap method (5,000 resamples) to test the mediating role of collective effervescence between synchronized movement and social bonding (see Figure 2 [Figure 2: see original paper]). Results indicated that synchronized movement positively predicted collective effervescence ($\beta = 0.80$, $SE = 0.05$, 95% CI [0.69, 0.90], not containing 0), verifying H2. Collective effervescence positively predicted social bonding ($\beta = 0.58$, $SE = 0.06$, 95% CI [0.44, 0.71], not containing 0), verifying H3. The indirect effect of collective effervescence was significant ($\beta = 0.46$, $SE = 0.07$, 95% CI [0.31, 0.60], not containing 0), indicating that collective effervescence significantly mediated the relationship between synchronized movement and social bonding, verifying H4.

2.2.5 Robustness Check

Some research suggests that interpersonal familiarity can influence social bonding, requiring control of participants' familiarity when examining social bonding (Wolf et al., 2016). Therefore, this study included familiarity as a control variable in the model to conduct a robustness check of the research findings.

Experiment 1, using the silent disco paradigm to manipulate synchronized movement, demonstrated the influence of synchronized movement (synchronized movement vs. complete no-movement) on social bonding and the mediating role of collective effervescence. Compared with the complete no-movement condition, participants who performed synchronized movement were more likely to experience collective effervescence, which in turn promoted social bonding. This study is the first to prove that social life synchronized movement can promote social bonding even without a musical background, with collective effervescence playing a mediating role, providing empirical support for the affective theory of synchronized movement. That is, synchronized activities change individuals' emotional experiences, increase collective effervescence, promote self-other fusion, and thereby increase social intimacy.

Experiment 2

Experiment 2 aimed to build upon Experiment 1 by further testing the moderating role of group size—that is, whether group size moderates the mediated effect of synchronized movement on social bonding through collective effervescence.

3.1.1 Participants

Using G*Power 3.1.9.2, with an expected medium effect size of $f = 0.25$, $\alpha = 0.05$, and statistical power of $1 - \beta = 0.80$, the results indicated that 128 participants were needed. This study recruited 136 high school students. Eight participants were excluded because they reported being close friends, resulting in a final sample of 128 valid participants, including 57 males and 71 females. The mean age of participants was 16.82 ± 2.37 years.

3.1.2 Experimental Design

This experiment used a 2 (synchronized movement vs. complete no-movement) \times 2 (large group size vs. small group size) completely randomized design. Synchronized movement was the independent variable, group size was the moderating variable, collective effervescence was the mediating variable, and social bonding was the dependent variable.

3.1.3 Materials and Measures

Synchronized Movement: Same as in Study 1. The internal consistency coefficient for the synchronized movement manipulation check in this study was 0.86.

Group Size: Following previous research, this study randomly assigned participants to 4-person small groups or 16-person large groups, with this classification

based on generally reasonable group sizes in the sports domain (Moreland et al., 2018). Participants randomly assigned to a team were asked whether they knew each other, with one item measuring familiarity to ensure participants in each team were strangers.

Collective Effervescence: Same as in Study 1. The internal consistency coefficient in this study was 0.80.

Social Bonding: Same as in Study 1. The internal consistency coefficient in this study was 0.88.

Control variables and operations were the same as in Experiment 1.

3.1.4 Procedure

First, participants ($N = 128$) were randomly assigned to one of four conditions: 4-person small group \times synchronized movement, 4-person small group \times complete no-movement, 16-person large group \times synchronized movement, and 16-person large group \times complete no-movement. Considering the large number of 4-person teams in the small group condition, an assistant was added to help with grouping to ensure consistent timing across groups. Subsequently, one item measuring familiarity was administered to ensure participants in each group were strangers.

Second, the experimenter informed participants: “You will participate in a team performance task. In this task, you will perform a table-tapping dance in a specific manner accompanied by a rhythmic sound.” Participants in a team sat together at a table, and the experimenter explained that they would hear a rhythm with three beats per measure through individual headphones. Therefore, they would execute three consecutive movements in each sound beat—one movement per beat. The experimenter then played a demonstration video of the table-tapping dance for participants.

Third, after watching the demonstration video, participants practiced the movements on their own without sound. During this period, the experimenter corrected any movement errors. After all participants indicated familiarity with the movements, they practiced at least twice to verify they had learned and were familiar with the correct movements. Once familiar, the experimenter informed participants: “Next, each of you will hear a 3-minute sound rhythm through individual headphones. During these 3 minutes, please focus on the sound beat you are hearing to execute the movements. Please note that you may hear a different version of the sound beat than other participants. Therefore, please pay special attention to the sound beat you hear through your headphones.” Participants then listened to the rhythm once without executing movements, after which they were reminded: “Please focus on the sound beat you hear through your headphones and begin executing movements when the sound beat starts.”

Finally, in the synchronized condition, all participants’ headphones in a group were connected to a single MP3 player, and they heard the same 128 BPM musi-

cal beat. The MP3 player and wires were hidden in a cardboard box to prevent participants from knowing whether they were all connected to the same MP3 player. In the complete no-movement condition, participants did not execute any movements and were allowed to rest for a few minutes before completing the questionnaire. After participants completed the synchronized movement task, the experimenter told all participants they had performed well and distributed questionnaires containing the synchrony effectiveness manipulation check, collective effervescence, social bonding, and demographic variables. After participants completed the questionnaires, the experimenter explained the study's purpose and expressed gratitude.

3.2.1 Familiarity Check

Across all groups, 78.6% of participants did not know each other. Therefore, the potential influence of pre-experimental familiarity among participants on the results could be ruled out.

3.2.2 Synchronized Movement Manipulation Check

An independent samples *t*-test was conducted to verify the effectiveness of the synchronized movement manipulation. Results showed a significant difference between the two groups in scores on the synchrony perception items, with the synchronized movement group ($M_{\text{synchronized}} = 5.10$, $SD = 0.71$) scoring significantly higher than the no-movement group ($M_{\text{no-movement}} = 2.79$, $SD = 0.79$; $t(126) = 17.35$, $p < 0.001$, Cohen's $d = 3.07$). This indicates that the designed movement materials effectively manipulated participants' synchronized movement.

3.2.3 Participants' Collective Effervescence and Social Bonding

A two-way ANOVA was conducted with synchronized movement as the independent variable and group size as the moderating variable, with collective effervescence as the dependent variable. The main effect of synchronized movement on collective effervescence was significant, $F(1, 126) = 43.40$, $p < 0.001$, partial $\eta^2 = 0.259$. The synchronized movement group scored significantly higher on collective effervescence ($M = 4.34$) than the no-movement group ($M = 3.65$). The main effect of group size on collective effervescence was significant, $F(1, 126) = 15.62$, $p < 0.001$, partial $\eta^2 = 0.112$. The large group size condition scored significantly higher on collective effervescence ($M = 4.20$) than the small group size condition ($M = 3.79$). The interaction between synchronized movement and group size on collective effervescence was significant, $F(1, 126) = 4.24$, $p = 0.042$, partial $\eta^2 = 0.033$. Simple effects analysis showed that under the synchronized movement condition, the large group size condition scored significantly higher on collective effervescence than the small group size condition ($M_{\text{large}} = 4.66$, $SD = 0.11$; $M_{\text{small}} = 4.02$, $SD = 0.11$; $F(1, 124) = 18.07$, $p < 0.001$, partial $\eta^2 = 0.127$), supporting H5. Under the no-

movement condition, group size did not significantly differ on collective effervescence ($M_{\text{large}} = 3.75$, $SD = 0.11$; $M_{\text{small}} = 3.55$, $SD = 0.11$; $F(1, 124) = 1.79$, $p = 0.183$, partial $\eta^2 = 0.014$). See Figure 3 [Figure 3: see original paper].

A two-way ANOVA was conducted with synchronized movement as the independent variable and group size as the moderating variable, with social bonding as the dependent variable. Results showed that the main effect of synchronized movement on social bonding was significant, $F(1, 126) = 36.90$, $p < 0.001$, partial $\eta^2 = 0.229$. The synchronized movement condition scored significantly higher on social bonding ($M = 4.56$) than the no-movement condition ($M = 3.78$). The main effect of group size on social bonding was significant, $F(1, 126) = 8.17$, $p = 0.005$, partial $\eta^2 = 0.062$. The large group size condition scored significantly higher on social bonding ($M = 4.35$) than the small group size condition ($M = 3.98$). The interaction between synchronized movement and group size on social bonding was significant, $F(1, 126) = 4.35$, $p = 0.039$, partial $\eta^2 = 0.034$. Simple effects analysis showed that under the synchronized movement condition, the large group size condition scored significantly higher on social bonding than the small group size condition ($M_{\text{large}} = 4.89$, $SD = 0.13$; $M_{\text{small}} = 4.24$, $SD = 0.13$; $F(1, 124) = 12.22$, $p < 0.01$, partial $\eta^2 = 0.090$). Under the no-movement condition, group size did not significantly differ on social bonding ($M_{\text{large}} = 3.82$, $SD = 0.13$; $M_{\text{small}} = 3.72$, $SD = 0.13$; $F(1, 124) = 0.30$, $p = 0.585$, partial $\eta^2 = 0.002$). See Figure 4 [Figure 4: see original paper].

3.2.4 Moderated Mediation Effect Test

Using the bootstrap method with Hayes's (2013) SPSS PROCESS macro (Model 8), we calculated indirect effects under different conditions of the moderating variable with the research sample size set at 5,000. The indirect effect of synchronized movement on social bonding through collective effervescence was significant under both group size conditions. Under the small group size condition, the indirect effect was significant, with an effect size of 0.40, 95% CI [0.15, 0.62]. Under the large group size condition, the indirect effect was significant, with an effect size of 0.77, 95% CI [0.50, 1.04]. Thus, compared with small group size, large-group synchronized movement had a stronger effect on social bonding through arousing collective effervescence. Additionally, the moderated mediation effect was significant, with an effect size of 0.37, 95% CI [0.02, 0.75].

In summary, these results indicate that group size has a moderating effect on the prediction of social bonding through collective effervescence, verifying H6. See Table 1 .

Table 1 Moderated Mediation Effect Analysis

Small Group Size	Large Group Size	Mediated Moderation Effect
Boot SE [0.15, 0.62]	95% CI [0.50, 1.04]	Boot SE [0.02, 0.75]

3.2.5 Robustness Check

This study included familiarity as a control variable in the model to conduct a robustness check and rule out potential interference from this factor. The robustness check results showed no substantive differences from the results without familiarity, confirming the model's robustness.

Experiment 2 confirmed that as group size continuously expands, the social bonding effect of synchronized movement becomes stronger, supporting H5. More importantly, the results confirmed that group size moderates the influence of synchronized movement on social bonding through collective effervescence, supporting H6. These conclusions validate Jackson et al.'s (2018) viewpoint that collective effervescence is more highly aroused in large-group contexts and tends to occur more in larger group size conditions. This experimental conclusion refines the strength of synchronized movement's social bonding effects under different size conditions, explaining why social bonding is higher in large-scale group environments—because higher levels of collective effervescence are generated in large group sizes.

Experiment 3

Experiment 2 examined the model using student samples, making it difficult to guarantee the external validity of the research conclusions. Therefore, Experiment 3 selected adult participants to replicate the full model and improve the external validity of the research conclusions (Qin et al., 2018).

4.1.1 Research Procedure and Sample

Based on Experiment 2's design, Experiment 3 used G*Power 3.1 to determine that 128 participants were needed to achieve 80% statistical power at $\alpha = 0.05$ with a medium effect size of $f = 0.25$. This study selected 130 employees from two project departments of a state-owned construction enterprise in Guizhou Province. After excluding 2 participants who did not complete the post-test, the final sample consisted of 128 valid participants, including 95 males and 33 females. The mean age was 37.42 ± 10.62 years. Participants were selected from two newly established project departments of a construction enterprise branch in Guizhou Province. Since these were newly established departments, only a few employees were familiar with each other, making it easy to control for familiarity. During participant assignment, participants in each team were randomly selected from different departments of the two project departments to

reduce familiarity within a team. After team assignment, one item measuring familiarity was administered before the experiment to further adjust and assign familiar employees to different groups, ensuring participants in each group were strangers.

4.1.3 Materials

All research variables and control variable measures were identical to those in Experiment 2. The internal consistency coefficients for the synchronized movement manipulation check, collective effervescence, and social bonding were 0.94, 0.922, and 0.935, respectively.

4.2.1 Familiarity Check

Across all groups, 87.1% of participants did not know each other. Therefore, the potential influence of pre-experimental familiarity among participants on the results could be ruled out.

4.2.2 Synchronized Movement Manipulation Check

An independent samples *t*-test was conducted to verify the effectiveness of the synchronized movement manipulation. Results showed that the synchronized movement group scored significantly higher on the synchrony perception items than the no-movement group ($M_{\text{synchronized}} = 5.62$, $SD = 0.53$; $M_{\text{no-movement}} = 2.30$, $SD = 0.77$; $t(126) = 28.47$, $p < 0.001$, Cohen's $d = 5.02$). This indicates that the designed movement materials effectively manipulated participants' synchronized movement.

4.2.3 Participants' Collective Effervescence and Social Bonding

A two-way ANOVA was conducted with synchronized movement as the independent variable and group size as the moderating variable, with collective effervescence as the dependent variable. Results showed that the main effect of synchronized movement on collective effervescence was significant, $F(1, 126) = 596.16$, $p < 0.001$, partial $\eta^2 = 0.828$. The synchronized movement group scored significantly higher on collective effervescence ($M = 5.29$) than the no-movement group ($M = 3.20$). The main effect of group size on collective effervescence was significant, $F(1, 126) = 17.09$, $p < 0.001$, partial $\eta^2 = 0.121$. The large group size condition scored significantly higher on collective effervescence ($M = 4.42$) than the small group size condition ($M = 4.07$). The interaction between synchronized movement and group size on collective effervescence was significant, $F(1, 126) = 6.43$, $p = 0.012$, partial $\eta^2 = 0.049$. Simple effects analysis showed that under the synchronized movement condition, the large group size condition scored significantly higher on collective effervescence than the small group size condition ($M_{\text{large}} = 5.48$, $SD = 0.09$; $M_{\text{small}} = 5.01$, $SD = 0.09$; $F(1, 124) = 22.24$, $p < 0.01$, partial $\eta^2 = 0.152$), again verifying H5. Under the no-movement condition, group size did not significantly differ on col-

lective effervescence ($M_{\text{large}} = 3.27$, $SD = 0.09$; $M_{\text{small}} = 3.14$, $SD = 0.09$; $F(1, 124) = 1.28$, $p = 0.260$, partial $\eta^2 = 0.010$). See Figure 5 [Figure 5: see original paper].

A two-way ANOVA was conducted with synchronized movement as the independent variable and group size as the moderating variable, with social bonding as the dependent variable. Results showed that the main effect of synchronized movement on social bonding was significant, $F(1, 126) = 1053.41$, $p < 0.001$, partial $\eta^2 = 0.895$. The synchronized movement condition scored significantly higher on social bonding ($M = 5.40$) than the no-movement condition ($M = 3.09$). The main effect of group size on social bonding was significant, $F(1, 126) = 22.75$, $p < 0.001$, partial $\eta^2 = 0.155$. The large group size condition scored significantly higher on social bonding ($M = 4.41$) than the small group size condition ($M = 4.07$). The interaction between synchronized movement and group size on social bonding was significant, $F(1, 126) = 8.44$, $p = 0.004$, partial $\eta^2 = 0.064$. Simple effects analysis showed that under the synchronized movement condition, the large group size condition scored significantly higher on social bonding than the small group size condition ($M_{\text{large}} = 5.57$, $SD = 0.07$; $M_{\text{small}} = 5.13$, $SD = 0.07$; $F(1, 124) = 29.46$, $p < 0.01$, partial $\eta^2 = 0.192$). Under the no-movement condition, group size did not significantly differ on social bonding ($M_{\text{large}} = 3.15$, $SD = 0.07$; $M_{\text{small}} = 3.02$, $SD = 0.07$; $F(1, 124) = 1.74$, $p = 0.190$, partial $\eta^2 = 0.014$). See Figure 6 [Figure 6: see original paper].

4.2.4 Moderated Mediation Effect Test

Using the bootstrap method with Hayes's (2013) SPSS PROCESS macro (Model 8), we calculated indirect effects under different conditions of the moderating variable with the research sample size set at 5,000. The indirect effect of synchronized movement on social bonding through collective effervescence was significant under both group size conditions. Under the small group size condition, the indirect effect was significant, with an effect size of 0.66, Boot $SE = 0.19$, 95% CI [0.27, 0.99]. Under the large group size condition, the indirect effect was significant, with an effect size of 0.81, Boot $SE = 0.25$, 95% CI [0.32, 1.28]. Additionally, the moderated mediation effect was significant, with an effect size of 0.15, Boot $SE = 0.09$, 95% CI [0.03, 0.42]. H6 was again verified.

In summary, these results indicate that group size has a moderating effect on the prediction of social bonding through collective effervescence. The results of Experiment 3 again supported the conclusions of this study.

4.2.5 Robustness Check

This study included familiarity as a control variable in the model to conduct a robustness check and rule out potential interference from this factor. The robustness check results showed no substantive differences from the results without familiarity, confirming the model's robustness.

Experiment 3, conducted with a different participant population, again verified the conclusions of the previous experiments, further providing external validity and robustness for the research findings. First, synchronized movement can promote social bonding. Compared with the no-movement group, the synchronized movement group showed higher social bonding, verifying H1. Additionally, collective effervescence played a mediating role in the relationship between synchronized movement and social bonding, verifying H2, H3, and H4. Second, the interaction between synchronized movement and group size had a significant impact on social bonding. Compared with small group size, the social bonding effect of synchronized movement was stronger in large group size conditions, verifying H5. Third, large-group synchronized movement enhanced the experience of collective effervescence, which in turn influenced social bonding, verifying H6 and again supporting the study's conclusions.

5.1 Theoretical and Practical Implications

First, this study confirms that synchronized movement without a musical background can promote social bonding. Based on the music-social bonding hypothesis, previous research has confirmed that music can strengthen social bonding among group members and attributed this effect to music (Tarr et al., 2017). In fact, music strengthens synchronized movement through rhythmic entrainment, and synchrony may be the key component through which joint musical activities promote social bonding (Li et al., 2024). When participants experience synchronous and asynchronous multisensory stimulation, they perceive themselves as more similar to synchronous partners, with synchrony more easily triggering illusions of bodily fusion than asynchrony (Paladino et al., 2010). The fusion of identity between self and others or the blurring of self-other boundaries prompts individuals to view themselves as components of the collective, thereby stimulating self-sacrificial pro-group behavior. Therefore, we adopted the silent disco paradigm to manipulate synchronized movement, separating music to independently examine synchronized movement's influence on social bonding. This study is the first to prove that synchronized movement can still promote social bonding even without a musical background, distinguishing the confounding influence of music and synchronized movement on social bonding identified in previous studies.

Second, this study enriches the literature on the collective effervescence effect of large-group synchronized movement. Existing research on group size in synchronized movement has primarily focused on small-group synchrony, exploring the effects of synchronized movement in small-group contexts on social impressions (Cheng et al., 2020), memory (Von Zimmermann, 2016), work stress among enterprise employees (Göriz & Rennung, 2019), and prosocial behavior in infants (Cirelli et al., 2017). Few studies have analyzed the influence of synchronized

movement on collective effervescence in large-group contexts. Existing research has overemphasized dyadic synchrony, with group size limited to one-on-one interactions, lacking comparisons of differences across various group sizes. Therefore, this study embedded group size into the main research framework of synchronized movement, examining for the first time the moderating role of group size on the collective effervescence effect of social life synchronized movement, establishing boundary conditions for the main effect and constructing a clearer framework in both theoretical and applied domains. This greatly expands research in the field of large-scale group synchronized movement. Simultaneously, this study verifies the hive hypothesis and related viewpoints proposed by previous researchers—that group members in large-scale contexts easily share emotions, large-group synchronized behavior utilizes emotional resources to function in social bonding, and the positive influence effect of collective effervescence is more pronounced in large groups than in small groups (Jackson et al., 2018; Mogan et al., 2017).

Third, this study confirms the collective effervescence effect of social life synchronized movement and supplements the emotional mechanism underlying synchronized movement's social bonding effect. This study is the first to prove that social life synchronized movement, like synchronized movement in collective religious and secular rituals, can awaken collective effervescence. It also verifies that social life synchronized movement has certain compensatory and substitutive effects for collective ritual synchronized movement (Xue & Yin, 2023). Early research focused more on the neurobiological mechanisms of synchrony (Dunbar et al., 2016; Tarr et al., 2017; Sullivan & Blacker, 2017)—that is, the positive influence of synchronized movement on social responses occurs through activating the brain's endogenous opioid system and releasing endorphins—while paying less attention to collective effervescence, the collective positive emotion originally arising from collective ritual synchrony. Collective effervescence easily triggers overlap between individual and collective selves, producing cognitive transformation that leads individuals to view themselves as members of a common category, helping to form high levels of social identity and trust (Hopkins et al., 2016). Additionally, while synchronized movement in collective religious and secular rituals has been confirmed to awaken collective effervescence (Charles et al., 2021; Páez et al., 2015), little is known about whether social life synchronized movement without symbolic meaning can also promote collective effervescence. Therefore, this study is the first to explore and analyze the emotional mechanism underlying the social bonding effect of synchronized movement in large-group contexts within the background of social life synchronized movement, and to confirm the existence of collective effervescence in the social synchrony process from the perspective of affective theory. It demonstrates that synchronized movement without symbolic meaning can promote social bonding through the arousal of collective effervescence, thus enriching the affective theoretical explanation of synchronized movement's social bonding effect. Based on Durkheim's perspective and collective effervescence theory, this study reveals and verifies the mechanism through which large-scale synchro-

nized movement in social life promotes social bonding, explaining why humans have developed large-scale synchronized movement during evolution and how synchronized movement can break time constraints to enable people to simultaneously establish social bonds with multiple individuals, not limited to the one-on-one physical grooming used by primates to maintain social relations.

Fourth, domestic and international research on synchronized movement has typically used experimental methods where participants perform synchronized movements accompanied by familiar music. Synchronized movement may be constrained by music familiarity, making it difficult to reveal causal relationships in dynamic group environments accompanied by music or rhythm. To address this limitation, this study adopted the “silent disco” paradigm, an effective method for studying physiological and psychological changes related to synchronized movement that provides rigorous manipulation of synchronized movement. In the silent disco paradigm, each participant wears headphones to receive information, thereby achieving synchronized or non-synchronized states, which facilitates precise manipulation of synchronized movement. In this paradigm, participants in a team receive instructions for synchronized movement through individual headphones, so any social bonding produced during the synchronization process can be attributed to synchronized movement itself, representing an innovative methodological approach.

Fifth, this study found that synchronized movement establishes social bonding among stranger groups through arousing collective effervescence. More importantly, the social bonding effect of synchronized movement is more pronounced in large-group contexts. This suggests that synchronized movement should be fully utilized in social group construction. For example, in group counseling activities themed around social bonding, large-group formats should be emphasized, with synchronized movement designed as the main group counseling activity to improve social intimacy among members.

The user wants me to translate a specific section from Chinese to English. The section is “### 5.2 Limitations and Future Directions” . Let me analyze the content:

1. It' s about limitations and future directions of a study on synchronized movement and collective effervescence.
2. It mentions experimental space limitations, visual contact between participants, and suggests using partitions.
3. It discusses three levels of synchronized movement: synchronized, non-synchronized, and no-movement, citing Rabinowitch & Meltzoff (2017) and Launay et al. (2013).
4. It explains why the study only used two levels (synchronized and no-movement) due to group size constraints (16-person groups).
5. It suggests future research should explore non-synchronized movement in large groups.
6. It mentions exploring marginal effects of group size, from 4-person to 16-person groups, and questions what happens at 100, 500+ people.

7. It suggests the effect might backfire at certain sizes.
8. It notes the study used experimental methods and the silent disco task paradigm.
9. It suggests future field experiments in natural environments.
10. It mentions specific real-world examples: square dancing in parks, broadcast calisthenics on campuses, and 扁担舞 (shoulder pole dance) in Zhuang ethnic minority festivals.

Key translation considerations: - The term “集体欢腾” is translated as “collective effervescence” (a standard sociological term from Durkheim) - “无声迪斯科任务范式” → “silent disco task paradigm” - “广场舞” → “square dancing” - “广播体操” → “broadcast calisthenics” - “扁担舞” → “shoulder pole dance” (this is a specific Zhuang ethnic dance) - “壮族” → “Zhuang ethnic minority” or “Zhuang ethnicity” - Author names should be kept as is (Rabinowitch & Meltzoff, Launay et al.) - Citations should be preserved exactly as [?] format - The structure should remain as a single section with paragraphs

Let me translate this carefully, maintaining academic tone and flow:

First paragraph: Discusses visual contact limitation and the three-level vs two-level design issue.

Second paragraph: Discusses marginal effects of group size scaling.

Third paragraph: Discusses field experiments and real-world contexts.

I need to ensure: - No Chinese characters remain - Proper academic English - Citations preserved - Flowing, readable prose - Maintain the same structure (single section with multiple paragraphs)

Let me draft the translation:

5.2 Limitations and Future Directions

First, due to limited experimental space, participants performed tasks face-to-face in pairs, which inevitably created visual contact. This visual contact may interfere with collective effervescence among participants. Future research should therefore consider the influence of visual contact on experimental results, potentially using partitions to separate participants and avoid such contact. Additionally, previous synchronized movement research has categorized movement into three levels: synchronized movement, non-synchronized movement, and complete no-movement [?, ?]. Because this study incorporated group size as a factor, implementing non-synchronized movement manipulation under 16-person large-group conditions proved difficult. Therefore, the experimental design divided synchronized movement into two levels: synchronized movement and complete no-movement. Future research should further consider how to rigorously manipulate non-synchronized movement in large-group contexts.

Second, future research could explore whether a marginal effect exists for group size on synchronized movement' s collective effervescence effect. This study

incorporated group size into the relationship between synchronized movement and collective effervescence, examining group size expansion from 4-person small groups to 16-person large groups. Whether the collective effervescence effect of synchronized movement will persist when group size expands to 100 people, 500 people, or even larger groups, or whether it will backfire and weaken collective effervescence after reaching a certain threshold, requires further verification.

Finally, this study primarily employed experimental methods. Future research could conduct field experiments to further compare the effects of synchronized movement across different group sizes in natural environments. This study manipulated synchronized movement through the silent disco task paradigm, which, while achieving the desired manipulation and controlling for factors that might interfere with collective effervescence, did not observe synchronized movement in real social life. Therefore, future research could focus on synchronized movement in real-world scenarios, observing its effects under different group sizes in natural environments such as square dancing in parks, broadcast calisthenics on campuses, and shoulder pole dance at Zhuang ethnic minority festivals. Conducting field experiments based on these real-world contexts would make research results more authentic and practical.

Wait, I need to check the citation format. The original has “(Rabinowitch & Meltzoff, 2017; Launay et al., 2013)” which should be converted to [?] format. The user said “PRESERVE ALL CITATIONS exactly - keep [?], ??, (??) unchanged” . But the original text uses parenthetical citations, not LaTeX \cite commands. Let me re-read the instruction.

The instruction says: “PRESERVE ALL CITATIONS exactly - keep [?], ??, (??) unchanged” . This suggests that if the original has [?], I should keep it. But the original has “(Rabinowitch & Meltzoff, 2017; Launay et al., 2013)” . This is not in [?] format.

Looking at the broader context, the user provided a “SECTION TO TRANSLATE” that already appears to be partially translated or is in a mixed format. Let me check the original Chinese text more carefully.

Actually, looking at the text provided in “SECTION TO TRANSLATE” , it seems to already be in English but contains some Chinese characters and references that need handling. Wait, no - the user said “Translate ONLY this section from Chinese to English” but the text provided looks like it’ s already mostly English with some Chinese terms mixed in.

Let me re-read the prompt more carefully. The user says:

“SECTION TO TRANSLATE: ### 5.2 Limitations and Future Directions

First, due to limited experimental space, participants performed tasks face-to-face in pairs, inevitably creating visual contact. Visual contact may interfere with collective effervescence among participants. Future research should therefore consider the influence of visual contact on experimental results, potentially

using partitions to separate participants and avoid visual contact. Additionally, previous synchronized movement research has categorized synchronized movement into three levels: synchronized movement, non-synchronized movement, and complete no-movement (Rabinowitch & Meltzoff, 2017; Launay et al., 2013). Because this study incorporated group size into synchronized movement, it was difficult to implement non-synchronized movement manipulation under 16-person large-group conditions. Therefore, this experimental design divided synchronized movement into two levels: synchronized movement and complete no-movement. Future research should further consider how to rigorously manipulate non-synchronized movement in large-group contexts.

Second, future research could further explore whether there is a marginal effect of group size on synchronized movement's collective effervescence effect. This study incorporated group size into the relationship between synchronized movement and collective effervescence, discussing group size expansion from 4-person small groups to 16-person large groups. Whether the collective effervescence effect of synchronized movement will still occur when group size expands to 100 people, 500 people, or even larger groups, or whether it will backfire and weaken collective effervescence after reaching a certain group size, requires further verification.

Finally, this study primarily employed experimental methods. Future research could conduct field experiments to further compare the effects of different group sizes of synchronized movement in natural environments. This study manipulated synchronized movement through the silent disco task paradigm, which, while achieving manipulation effects and controlling for factors that might interfere with collective effervescence, did not observe real social life synchronized movement. Therefore, future research could focus on real-scenario synchronized movement as the main subject, observing synchronized movement effects under different group sizes in real environments such as square dancing in parks, broadcast calisthenics on campuses, and 扁担舞 (shoulder pole dance) in Zhuang ethnic minority festivals. Conducting field experiments based on real-world### Conclusion

This study reached three main conclusions: First, all three experiments demonstrated that synchronized movement can produce social bonding effects among stranger groups. Compared with the no-movement group, synchronized movement groups showed higher social bonding. Additionally, collective effervescence mediated the relationship between synchronized movement and social bonding. Second, Experiments 2 and 3 confirmed the moderating role of group size on synchronized movement and social bonding. When large-group synchronized movement occurs, the social bonding effect produced in stranger group environments is more significant than in small-group contexts. Furthermore, collective effervescence continued to play a mediating role. This conclusion confirms affective theory—that synchronized movement performed in large-group contexts more easily arouses collective effervescence, making team members' bonds tighter. Third, Experiment 3, conducted with different participant populations, yielded

conclusions consistent with Experiment 2, thereby enhancing the external validity and robustness of the research findings.

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