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# Synchronized Behavior Increases Assessments of the Formidability and Cohesion of Coalitions

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The complete dataset for the study reported in this paper, and the stimuli employed, are included in the Electronic Supplementary Material, available from the publisher's website upon publication; other components of the Supplementary Materials are appended to this document.

## Abstract

Synchronized behavior is a common feature of martial drills and military parades in many societies. Hagen and colleagues (Hagen & Bryant, 2003; Hagen & Hammerstein, 2009) hypothesized that the intentional enactment of synchronized behavior evolved as a means of signaling coalitional strength, as individuals who can synchronize are able to act in concert in agonistic contexts. Previous research has explored either the subjective consequences of synchrony for participants in synchronized behaviors or the effect of synchrony on observers' impressions of rapport among the synchronized actors. Critically, left untested is the central tenet that, by communicating that the individuals constitute a coordinated unit, synchronized behaviors signal elevated fighting capacity. We tested this prediction in two studies by asking large U.S. samples to judge the envisioned physical formidability – previously demonstrated to summarize assessments of diverse determinants of fighting capacity – of U.S. soldiers or terrorists on the basis of audio tracks of either synchronous or asynchronous footsteps. Consonant with the agonistic signaling hypothesis, participants judged the synchronized target individuals to be larger and more muscular than the unsynchronized individuals, an effect mediated by their assessment that the former collectively constitute a single unified entity. Although synchronized footsteps also enhanced listeners' perceptions of social bonding among the target individuals, this assessment did not mediate their judgments of elevated formidability, suggesting that synchrony primarily signals fighting capacity via revealed entitativity rather than inferred motivation.

Keywords: synchrony; signaling; fighting capacity; entitativity; perceived coalitional quality

## 1.0 Introduction

**1.1 Synchronized behavior: theory and prior research.** Across widely diverse cultures, and among societies of very different scales, synchronized behavior is a prominent feature of rituals and collective displays. Over the last two decades a growing literature has explored the psychological effects of synchronized movement and synchronized sound production (reviewed in Keller et al., 2014). At an elementary level, the effects of synchrony can be dichotomized into two classes, namely the impact that synchrony has on participants in such activities, and the impact that it has on observers. In a seminal book, McNeill (1995) proposed that synchronized movement enhances social bonding among participants, and that, over the course of human history, this process has played a pivotal role in the rise of cooperation. Pushing the roots of synchrony even farther back in time, Hagen and colleagues (Hagen & Bryant, 2003; Hagen & Hammerstein, 2009) argued that music and dance derive from phylogenetically ancient coordinated territorial defense signals; in humans, these signals were refined to communicate the size, cohesiveness, and capabilities of coalitions, as intentionally enacted synchronized behavior inherently requires both the ability and the motivation to effectively coordinate actions. In both of these accounts, participation in synchrony is associated with positive affects and self-concepts linked to social bonding – subjectively, individuals find participation in synchrony rewarding, experience themselves as closer to their fellow synchronizers, and are thus motivated to both aid their fellows and act in concert with them. However, differentiating their position, Hagen and colleagues propose that the driving force behind this phenomenon is the communicative function of intentionally synchronized behavior – the subjective consequences of participation in synchrony are explicable as the motivational and attitudinal concomitants of a system that exists primarily to convey information regarding the

nature of a coalition (see also Merker, 2000; Huron, 2001; Fitch, 2006; Merker et al., 2009; Phillips-Silver et al., 2010). If synchrony serves to communicate information regarding coalitional strength, then, logically, there are two categories of recipients of this signal, namely fellow members of the synchronized group and outside observers who constitute either prospective allies or potential enemies. Consonant with their thesis, Hagen and Bryant (2003) demonstrated that listeners attend to musical synchrony in judging the degree of affinity and solidarity obtaining among musicians.

Musical performance – the focus of Hagen and colleagues’ theorizing – is a striking example of intentionally enacted synchronized behavior. However, this is not the only starting point for such theorizing. Coming at the problem of cooperation from the perspective of prior work on postural mirroring (LaFrance, 1985), LaFrance (1990) offered a brief theoretical sketch that, while lacking ultimate explanations or phylogenetic accounts, nevertheless directly parallels Hagen et al.’s perspective on the informational value of synchrony in communicating cohesiveness to both in-group and out-group individuals.

Although Hagen and Bryant’s signaling paper has been highly cited in work exploring the psychology of synchrony, consonant with McNeill’s initial focus, to date, much of this literature has focused not on outwardly signaling coalitional quality in the service of intimidating rivals and attracting allies, but rather on the subjective and behavioral consequences of participation in synchrony, particularly as they pertain to issues of conformity, cohesion, bonding, solidarity, prosociality, and cooperation (see, for example, Wiltermuth & Heath, 2009; Hove & Risen, 2009; Cohen et al., 2010; Kirschner & Tomasello, 2010; Valdesolo et al., 2010; Kokal et al., 2011; Valdesolo & DeSteno, 2011; Wiltermuth, 2012b; Wiltermuth, 2012a; Fischer et al., 2013; Launay et al., 2013; Reddish et al., 2013a; Reddish et al., 2013b; Kirschner & Ilari,

2014; Cirelli et al., 2014a; Cirelli et al., 2014b; Fessler & Holbrook, 2014; Lumsden et al., 2014; Sullivan et al., 2014; Dong et al., 2015; Rabinowitch & Knafo-Noam, 2015; Sullivan et al., 2015; Tarr et al., 2015; Zimmermann & Richardson, 2015; Tarr et al., in press; see also Weinstein et al., 2016). In contrast, the question of the interpretation of signals by non-participants has received less attention in this body of work (see Dong et al., 2015, as well as Lumsden et al., 2012, for exceptions).

As noted above, LaFrance's ideas on the communicative affordances of synchrony stemmed from investigations of postural mimicry. LaFrance's work is thus part of a larger literature examining apparently unintentional behavioral entrainment that occurs spontaneously in the course of quotidian social interaction. While differing in both context and emic conceptual framing from consciously orchestrated collective behaviors such as musical performances, rituals, and military drills, what is sometimes termed "interactional synchrony" (Chartrand & Lakin, 2013) nevertheless potentially presents some similar communicative affordances, stemming in this case from the bi-directional causal relationship between positive engagement among interactants and behavioral entrainment (Lakin et al., 2003). Correspondingly, while apparently unaware of Hagen and colleagues' work on orchestrated synchrony, investigators examining interactional synchrony and related phenomena (e.g., behavioral mimicry) have explored the effects of synchronized movements on observers' impressions of the relationships obtaining between synchronizing actors. Miles et al. (2009) presented participants with either animated walking stick figures or audio recordings of people walking, varying the degree of synchrony among the walkers in each. Participants judged the walkers to have the greatest degree of rapport with one another when they were the most synchronized (i.e., either entirely in-phase or entirely anti-phase with one another). Lakens (2010) demonstrated that both waving

stick figures and videotaped waving people were judged to have greater entitativity (the extent to which individuals are seen as constituting a unified group) when they displayed synchronous movements. Lakens and Stel (2011) obtained similar results for judgments of both rapport and entitativity using videos of waving people, with a follow-up experiment showing that judgments of rapport were greater when participants believed that the synchrony manifested spontaneously rather than as a result of instruction from a third party; in contrast, entitativity judgments were comparatively robust to such information. Using videos of people walking, Edelman and Harring (2014) demonstrated that synchrony enhanced judgments of both entitativity and rapport, with the effect being stronger for the former than the latter. Hence, while the total number of studies to date is limited, and published findings derive from studies of British, Dutch, and U.S. university students (a narrow spectrum from which to generalize about species-typical human psychology [Henrich et al., 2010]), nevertheless, there is reasonable preliminary evidence that observers indeed interpret synchronized behavior as indicative of coalitional cohesion. Given the relationship between social cohesion and coalitional formidability, such findings in turn provide partial support for the broader thesis that synchronized behavior, whether intentional or spontaneous, offers an avenue whereby the fighting capacity of a coalition can be communicated.

In parallel with the efflorescence of research on synchrony in humans, a growing body of work examines synchrony in other species. In particular, consonant with both Hagen and colleagues' signaling theory and their approach grounded in evolutionary biology, investigators have documented the importance of synchronized behavior in coalitional signaling and aggression in a number of species, including cetaceans (Connor et al., 2006; Cusick & Herzing,

2014; Perelberg & Schuster, 2008; Senigaglia & Whitehead, 2012; Senigaglia et al., 2012), birds (Hall & Magrath, 2007), and primates (Fedurek et al., 2013).

Critically, despite the facts that i) researchers studying animal behavior have long identified agonistic conflict as a principal driver of coalitional formation, ii) students of human behavior have similarly viewed inter-group competition and violence as a key selective pressure in the evolution of human cooperation (Choi & Bowles, 2007; Bowles, 2009; Boyd & Richerson, 2009), and iii) such conflict plays a central role in Hagen and colleagues' much-cited papers on synchrony-as-signal, nevertheless, with only a few exceptions, research on synchrony in humans has neglected aggression and conflict. Wiltermuth demonstrated that experimentally induced synchrony increases compliance with instructions to aggress against an outgroup (2012b) or destroy insects (2012a), and we have previously shown that walking in synch with another man decreases men's estimations of the physical formidability of a hypothetical antagonist (Fessler & Holbrook 2014), a measure that, as we discuss below, has been demonstrated to summarize the threat that a hostile other is seen as posing. However, while addressing aggression and conflict, all three of these findings pertain exclusively to the effects of synchrony on those participating in it, and thus do not speak to a key feature of the signaling model, namely the affordances for communicating features of the synchronized group to outsiders. Hence, against the backdrop of existing theory and empirical findings, a central prediction stands untested, namely that observers will judge a group of synchronized individuals both as more united and as constituting a more formidable fighting force than an equivalent group of unsynchronized individuals. Here, we investigate this prediction.

**1.2 Background of the present study.** Given strong cultural associations between military training and synchronized behavior, in designing an investigation of the relationship

between synchrony and assessments of formidability, care must be taken to avoid demand characteristics. For example, were we to rely principally on overt questions regarding fighting capacity, participants might be more likely to discern the hypothesis at issue. To reduce demand characteristics, we therefore employed as key dependent measures assessments that, on the surface, appear not to be directly linked to fighting capacity in the modern era. Below we explain the logic behind, and evidence supporting, these measures.

In situations of agonistic conflict, individuals must quickly decide whether to fight, flee, appease, or negotiate, with a principal determinant of the optimal decision being the threat that the opponent poses, importantly including the relative fighting capacity of the two parties. In humans, relative fighting capacity is the product of many attributes, including martial skill, access to weapons, and the presence of allies. Assessing many dimensions quickly can be facilitated through the use of a summary representation that acts as a running tally across variables. In hand-to-hand human combat, physical size and strength – dimensions that are robustly correlated – are important determinants of fighting capacity (although the relative importance of each varies somewhat between studies -- see Von Rueden et al., 2008; Collier et al., 2012; Sell et al., 2012). Correspondingly, we can expect that one phylogenetically ancient cognitive capacity is the ability to represent relative size and strength in the context of agonistic decision-making. Together with our colleagues, we have previously proposed that, in humans, this representation serves as a summary of diverse determinants of the threat posed by an antagonist: a minds-eye image of the envisioned bodily attributes of an antagonist captures estimations of many features of the self and the other relevant to threat assessment (Fessler et al., 2012). Consistent with this thesis, being aware that an opponent is armed (Fessler et al., 2012) or is prone to take physical risks (Fessler et al., 2014a; Fessler et al., 2014c) increases observers'

estimates of his size and muscularity. Such estimates are similarly influenced by the observer's own physical strength (Fessler et al., 2014b) and, inversely, temporary incapacitation (Fessler & Holbrook, 2013a); having vulnerable children (Fessler et al., 2014d); being in a vulnerable phase of the menstrual cycle (Fessler et al., 2015); one's friends' physical proximity (Fessler & Holbrook, 2013b); and information concerning a target's ethnicity (Holbrook et al., 2016) or degree of commitment to a coalition and its agonistic objectives (Fessler et al., 2016).

Complementing these results, Yap et al. (2013) have shown that manipulating participants' sense of their social power inversely changes their estimates of another's size and weight. Similarly, Duguid and Goncalo (2012) have demonstrated that feeling powerful leads people to overestimate their own height and underestimate another's. Of particular relevance for the present study, attributes of an agonistic coalition are represented in the same manner, as participants' estimates of the physical formidability of a member of such a coalition are enhanced when participants are informed that the coalition's leader is effective, and diminished when they are informed that the coalition's leader is dead or ineffectual (Holbrook & Fessler, 2013). Taken together, these findings indicate that asking participants to estimate the physical size and muscularity of individuals who either are or are not moving synchronously can constitute an indirect means of measuring the effects of synchrony on assessments of coalitional formidability.

Employing participants' estimates of envisioned physical size and muscularity as a measure of estimated formidability entails two constraints on the nature of the stimuli to be used. First, the aforementioned framework concerns internal cognitive representations that summarize relative fighting capacity and threat, and in no way predicts that perception itself should be biased (indeed, given that this representational system is deployed in agonistic contexts, there is

every reason to expect perception to remain unbiased, as accuracy in this regard is essential should individuals come to blows). In order to access this representation, we ask participants to provide estimates of size and muscularity, yet, because perception remains unbiased, the stimuli on which such estimates are based must not provide perceptual cues of actual size and strength. Accordingly, the stimuli selected must not visually depict whole persons. Inspired by Miles et al. (2009), we therefore presented participants with audio recordings of footsteps that either were or were not synchronized. A second constraint imposed by the use of estimates of physical size and muscularity as a dependent measure is that the target individuals must be presented in such a way that they can be construed as potential combatants. The representational system at issue is deployed in situations of potential agonistic conflict, hence the meaning of participants' estimates hinges on an agonistic context being present (Fessler et al., 2014b). Indeed, because, in what appears to be a serially homologous application of the trait, the same envisioned dimensions are also used to represent prestige (Holbrook et al., 2016), merely presenting synchronized behavior absent an agonistic framing could well produce spurious responses. Employing a U.S. sample, we therefore framed the footsteps as the marching of military personnel. Lastly, note that, in an agonistic context, observers should attend to synchronized behavior whether the synchronized group is composed of actual or potential allies of the observer (as it is critical to know the strength of one's own coalition) or actual or potential enemies of the observer (as it is equally important to know the strength of one's adversaries). We therefore described the marching footsteps as those of either American soldiers or members of a terrorist organization, respectively, thereby exploring both classes of actors (allies and enemies) relevant in agonistic contexts.

The agonistic signaling hypothesis posits that the key features communicated by synchronized behavior are the size, cohesiveness, and capabilities of a coalition. Specifically, members of a coalition who synchronize their actions demonstrate in so doing that they are both able and motivated to act in concert, thereby presenting a well-coordinated team and a united front, features that enhance their coalition's fighting capacity. Observers should therefore conclude that, given a context in which fighting capacity is relevant, a synchronized coalition will act as a more effective single entity, and is correspondingly more formidable, than an unsynchronized coalition. These conclusions should obtain whether the observer's interests are aligned with the coalition at issue (in which case the coalition constitutes a potential ally) or opposed to the coalition at issue (in which case the coalition constitutes a potential enemy).

Both the propensity to act as a unit (i.e., cohesiveness) and the ability to coordinate actions likely frequently co-occur with the degree of affinity and emotional solidarity obtaining among the members of a coalition. Indeed, much of the existing literature on synchrony and related phenomena underscores the bidirectional causal relationship between cohesiveness and coordination capability on the one hand, and sentiments associated with bonding on the other hand: synchrony can cause feelings of bonding and closeness (e.g., Hove & Risen, 2009; Valdesolo et al., 2010; Valdesolo & DeSteno, 2011; Vacharkulksemsuk & Fredrickson, 2012; Launay et al., 2013; Fischer et al., 2013; Fessler & Holbrook, 2014; Lumsden et al., 2014; Rabinowitch & Knafo-Noam, 2015; Tarr et al., 2015), and feelings of bonding and closeness can lead to synchrony (e.g., Lakin et al., 2003; Vacharkulksemsuk & Fredrickson, 2012; Cheung et al., 2015). Importantly, however, cohesiveness and coordination capability are logically distinct from feelings of bonding and closeness – although sentiments frequently undergird actions, they are not isomorphic with them.

Of direct relevance to the question of gauging a coalition's fighting capacity, while feelings of bonding may facilitate subjective commitment (Fessler & Quintelier, 2013) to coalition-mates and their cause, by itself, such commitment does not necessarily translate into efficacy. Rather, in general, if an affectively tightly-bonded coalition is an effective fighting unit, this will largely be because its members act in concert and coordinate well with one another. Indeed, individuals whose interests are highly aligned, and who are able to communicate and plan efficaciously, will constitute an effective fighting unit whether or not they feel close to one another. In practice, it is likely that, by motivating commitment, communication, and planning, feelings of bonding enhance coalitional fighting capacity, and, conversely, recognition of coordinative capacity and aligned interests likely engenders feelings of bonding. However, if the question at issue is the signal value of synchronized behavior, then, because it is impossible to display synchrony without acting as a coordinated – and thus effective – unit, yet it is possible both to experience bonding without being effective and to display synchrony without experiencing bonding, judgments of fighting capacity should weight inferences regarding behavioral cohesion more than inferences regarding affective bonding. This suggests that, at least in agonistic contexts, measures of perceived sentiment, such as those employed by Hagen and Bryant (2003) and Miles et al. (2009), may not tap the most important attributes communicated by the signal at issue. Instead, the key feature may be entitativity, the extent to which the agents are perceived as constituting a single unit, as explored by Lakens (2010), Lakens and Stel (2011), and Edelman and Harring (2014). To test the subsidiary prediction that entitativity is more central to assessments of coalitional fighting capacity than is affective bonding, we employed both Hagen and Bryant's measure of perceived social closeness and cohesion and a measure of perceived entitativity augmented to address agonistic contexts.

## 2.0 Study 1

### 2.1 Methods

**2.1.1 Participants and overview of procedure.** All studies reported here were approved by the UCLA Office of the Human Research Protection Program. In our first study, 800 U.S. participants were recruited via Amazon's MechanicalTurk.com survey platform in exchange for \$0.40 for a study titled "Auditory Impressions", described as "listening to sounds of people, then answering questions about the way you imagine them." Data were pre-screened for completeness, repeat participation, U.S. citizenship, reported audio playback problems, and correctly answering two "catch questions". The final sample consisted of 698 adults (50.6% female; 76.5% White) ranging in age from 19 to 76 ( $M = 36.79$ ,  $SD = 12.50$ ).

In a 2 X 2 between-subjects design, participants were randomly assigned to listen to the sounds of two target individuals (framed as either a U.S. Soldier or Terrorist) marching (either Synchronously or Asynchronously; see ESM for details on stimuli production, the complete framing text, and the audio recordings used). Next, in counterbalanced order, participants estimated the targets' physical formidability, entitativity, and social closeness and cohesion (henceforth, for simplicity, termed *perceived bonding*).

Composite physical formidability was estimated by averaging standardized ratings of height, muscularity, and size, presented in random order ( $\alpha = .72$ ). Height was estimated in feet and inches; muscularity and size were estimated using 6-point pictorial arrays (see ESM Figure S1). Participants also completed a modified 6-item version of the Entitativity Scale (e.g., "I have the feeling the men can work together"; from Postmes et al. [n.d.], as presented in Lakens & Stel [2011]), including 3 novel items directly pertaining to agonistic behavior (e.g., "I feel these men

would be able to coordinate with each other to carry out an attack”), rated on a 7-point scale (1 = *Not at all*; 7 = *Extremely*  $\alpha = .91$ ; see ESM). Perceived interpersonal bonding between the targets was measured via a modified 7-item version of Hagen and Bryant’s Coalition Quality instrument (2003), using 8-point scales anchored for question relevance (e.g., “How much do you think these men like each other?”; 1 = *Very little*; 8 = *Very much*;  $\alpha = .73$ ; see ESM).

Finally, participants answered demographic items, including ancillary questions probing the perceived threat of terrorism (see ESM for details and analyses) and questions confirming that the audio playback had functioned correctly, and were debriefed.

## 2.2 Results

**2.2.1 Preliminary tests of order, target framing, and sex effects.** A MANOVA including order, Synchrony condition, and target Framing condition (Soldier vs. Terrorist) as predictors revealed no main effects of order or interactions between order and the Synchrony or Framing conditions on any of the outcome measures,  $ps > .24$ . Order was therefore dropped from further analyses.

There were significant main effects of Framing condition on estimated physical formidability, entitativity, and perceived bonding (consonant with the interpretation that our American participants view the U.S. military as better trained, better equipped, more unified, and thus possessing greater fighting capacity than terrorist organizations, each outcome was estimated to be greater when the targets were framed as U.S. soldiers than when framed as terrorists; see ESM Table S1). However, we observed no interactions between Framing and Synchrony condition for estimated physical formidability ( $p = .66$ ), entitativity ( $p = .64$ ), or perceived bonding ( $p = .067$ ). Accordingly, the Soldier and Terrorist conditions were combined

for subsequent tests of the effect of the Synchrony manipulation. (Controlling for Framing does not alter the significance or approximate magnitude of the effects of the Synchrony manipulation.)

We also assessed potential effects of sex, finding that women envisioned the targets as of greater physical formidability and entitativity than did men, with no effects of sex observed regarding the estimated degree of bonding (see ESM Table S2). As there were no observed interactions between Sex and Synchrony condition for any of the three outcome measures,  $p$ s > .53, Sex was not included in subsequent analyses.

**2.2.2 Effects of synchrony on envisioned physical formidability, entitativity, and perceived bonding.** As hypothesized, the target individual's envisioned physical formidability, entitativity, and bonding were greater for synchronous targets than for asynchronous targets (see Table 1).<sup>1</sup> Estimated envisioned physical formidability, entitativity, and bonding were all positively correlated (see Table 2).<sup>2</sup>

**2.2.2.1 Mediation analysis.** We conducted a mediation test to assess the relative contributions of envisioned bonding and entitativity to the heightened ratings of physical formidability observed in the Synchrony condition (see Figure 1). We utilized the bias-corrected bootstrapping procedure (5,000 samples) found in the INDIRECT macro for SPSS (Preacher & Hayes, 2008). We entered Synchrony condition as the independent variable, entitativity and perceived bonding scores as the mediating variables, and composite physical formidability as the dependent variable. As predicted, perceptions of relatively greater entitativity fully mediated the effects of the Synchrony condition on envisioned physical formidability. The direct effect of synchrony on envisioned physical formidability ( $b = .25$ ,  $SE = .06$ ,  $\beta = .16$ ,  $p < .001$ ) was no longer significant in the model ( $b = .08$ ,  $SE = .06$ ,  $\beta = .05$ ,  $p = .19$ ), whereas the indirect effect of

entitativity on envisioned physical formidability remained significant ( $b = .24, SE = .03, \beta = .34, p < .001$ ), and the confidence intervals did not overlap with zero (95% CI = [.099, .207]). By contrast, the indirect effect of perceived bonding on envisioned physical formidability was modest and of only marginal significance ( $b = .06, SE = .03, \beta = .08, p = .05; 95\% CI = [-.003, .062]$ ).

### **2.3 Discussion**

Results from Study 1 provide initial support for the prediction that, in an agonistic context, observers interpret synchronized behavior as revealing of a coalition's fighting capacity: participants envisioned the synchronized dyad as more physically formidable than the unsynchronized dyad, a result that was mediated by the effects of synchrony on perceived entitativity, the degree to which the dyad was seen to act as a single unit.

In order to ensure that participants would construe the context as agonistic, having described the target individuals as either U.S. soldiers or terrorists, we framed the recorded activity as “marching”. While this no doubt achieved the desired effect as regards context, it also potentially introduced a critical confound. Whether or not some version of McNeill's (1995) or Hagen and colleagues' (Hagen & Bryant, 2003; Hagen & Hammerstein, 2009) ideas is correct, it is a fact that military marching the world over frequently involves mandated synchrony – a fact of which many of our participants were no doubt aware. If proper martial marching requires synchrony, then marching out of synch may reveal that individuals are poorly trained or poorly disciplined. If envisioned physical formidability constitutes an umbrella representation that summarizes diverse aspects of fighting capacity, then martial efficacy should be one of the factors influencing this representation; indeed, as noted earlier, prior research documents that information regarding the efficacy of a terrorist group's leadership influences the envisioned

physical formidability of its members (Holbrook & Fessler, 2013). Hence, by describing the target individuals as “marching”, we may have inadvertently provided spurious grounds for evaluating fighting capacity; as a consequence, participants’ responses may have been entirely independent of any direct effects of synchronized behavior on assessments of coalitions – our findings may simply owe to participants’ prior knowledge of what constitutes proper marching.

In order to remove the aforementioned confound without reducing the martial nature of the framing, in Study 2 we retained all features of the design of Study 1, but changed the description of the recorded activity from “marching” to “on patrol”, as the latter is not associated with mandated synchrony. Lastly, as the asynchronous stimuli used in Study 1 were produced by manipulating the recordings in a number of ways, including altering the intervals between footsteps (see ESM), it is possible that these alterations changed the apparent speed with which the target individuals were walking. Slower, more laborious walking might indicate fatigue, fear, or lack of motivation, any or all of which would reduce assessments of formidability. In order to investigate and control for this additional possible confound, in Study 2 we asked participants to indicate how quickly the target individuals appeared to be walking.

## **3.0 Study 2**

### **3.1 Methods**

**3.1.1 Participants and overview of procedure.** 600 U.S. participants were recruited via Amazon’s MechanicalTurk.com survey platform in exchange for \$0.40 for a study described in identical terms to Study 1. Data were pre-screened as in Study 1, with the additional criterion that those who had participated in Study 1 were excluded, leaving a final sample consisting of 534 adults (46.3% female; 79.0% White) ranging in age from 18 to 74 ( $M = 34.37$ ,  $SD = 11.47$ ).

The conditions and materials utilized in Study 2 were the same as those of Study 1, save that the targets were described as having been recorded while “on patrol” rather than “marching” (see ESM for details). An additional item probed the perceived speed of the targets’ gait. Participants rated “How fast did the men seem to be walking?” according to a 7-point scale (1 = *Extremely slow*; 4 = *Moderate speed*; 7 = *Extremely fast*). As in Study 1, the measures of composite physical formidability ( $\alpha = .69$ ), entitativity ( $\alpha = .91$ ), and perceived bonding ( $\alpha = .76$ ) were reliable. Finally, participants answered the demographic items and were debriefed.

## 3.2 Results

**3.2.1 Preliminary tests of order, target framing, and sex effects.** A MANOVA including order, Synchrony condition, and target Framing condition (Soldier vs. Terrorist) as predictors revealed no main effects of order or interactions between order and the Synchrony or Framing conditions on any of the outcome measures,  $ps > .44$ . Order was therefore dropped from further analyses.

As observed in Study 1, there were significant effects of Framing condition on estimated physical formidability, entitativity, and bonding (each outcome was again estimated to be greater when the targets were framed as U.S. soldiers than when framed as terrorists; see ESM Table S6). As previously, we observed no significant interactions between Framing and Synchrony condition for estimates of entitativity ( $p = .54$ ) or bonding ( $p = .81$ ). However, in this sample, we did observe a marginally significant interaction between the Framing and Synchrony manipulations on estimated physical formidability ( $p = .05$ ). Therefore, the Framing condition was controlled for in subsequent analyses of the effects of the Synchrony manipulation. (As in Study 1, controlling for Framing does not alter the approximate significance or magnitude of the effects of the Synchrony manipulation.)

We also assessed potential effects of participant sex, finding that, as in Study 1, women envisioned the targets as of greater physical formidability and entitativity than did men, with no effects of Sex observed regarding the estimated degree of bonding (see ESM Table S7).

**3.2.2 Effects of synchrony on envisioned physical formidability, entitativity, and bonding.** Replicating the results of Study 1, the target individual's envisioned physical formidability, entitativity, and bonding were greater for synchronous targets than for asynchronous targets (see Table 3).<sup>3</sup> Estimated envisioned physical formidability, entitativity, and bonding were also positively correlated, as in Study 1 (see Table 4).<sup>4</sup>

**3.2.2.1 Effects of synchrony on perceived speed.** We next tested whether the effects of the Synchrony manipulation observed in Study 1 were related to perceptions of differing walking speed. Controlling for Framing condition, we observed no effect of Synchrony condition on the perceived walking speed of the targets,  $p = .24$ , nor was perceived speed significantly correlated with the envisioned physical formidability of the targets,  $r(531) = .03$ ,  $p = .49$ . However, there were positive correlations observed between perceived walking speed and both estimated entitativity,  $r(531) = .10$ ,  $p < .03$ , and perceived bonding,  $r(531) = .13$ ,  $p < .01$ .

**3.2.2.2 Mediation analysis.** We next conducted a mediation test, in the same manner as employed in Study 1, to assess the relative contributions of envisioned bonding and entitativity to the heightened ratings of physical formidability observed in the Synchrony condition (see Figure 3). We entered the Synchrony manipulation as the independent variable, entitativity and perceived bonding scores as the mediating variables, and composite physical formidability as the dependent variable, with Framing condition included as a covariate. In the model that emerged, perceptions of relatively greater entitativity partially mediated the effects of the Synchrony condition on envisioned physical formidability. The direct effect of synchrony on envisioned

physical formidability ( $b = .23, SE = .07, \beta = .15, p = .001$ ) was of reduced significance in the model ( $b = .15, SE = .06, \beta = .09, p = .02$ ), whereas the indirect effect of entitativity on envisioned physical formidability remained significant ( $b = .10, SE = .04, \beta = .14, p = .01$ ), and the confidence intervals did not overlap with zero (95% CI = [.006, .067]). By contrast, the indirect effect of perceived bonding on envisioned physical formidability was relatively modest and of only marginal significance ( $b = .07, SE = .04, \beta = .10, p = .05$ ; 95% CI = [.000, .046]).

### **3.3 Discussion**

Study 2 replicated the core finding of Study 1, namely that, in an agonistic context, synchronized target individuals, be they friend or foe, are conceptualized as more formidable than are those who are out of synch. Study 2 thus demonstrates that this pattern does not principally owe to our having presented the situation as one in which synchrony is mandated, as altering the framing of the footsteps from “marching” to “on patrol” does not change the overall pattern of results. Likewise, Study 2 confirmed that these patterns are not due to artifactual alterations in the apparent speed of walking introduced during the production of the stimuli, as participants’ perceptions of walking speed did not differ across conditions. Inspection of the results does suggest, however, that the principal methodological concern motivating Study 2 was not entirely unfounded: while the core patterns remain, changing the framing of the footsteps from “marching” to “on patrol” may have reduced the effect of condition somewhat (compare the effects sizes in Table 1 and Table 3 Table 1 and Table 3); likewise, whereas in Study 1 entitativity fully mediated the relationship between condition and envisioned formidability, in Study 2 this mediation was not complete. These ancillary observations raise the possibility that, consonant with the logic of the formidability representation hypothesis on which our methods are based, the targets’ envisioned size and strength may also have been influenced by their success at

achieving a martial goal, underscoring the importance of both replicating initial results and considering multiple possibilities when employing measures that tap summary representations.

#### **4.0 Discussion**

Hagen and colleagues (Hagen & Bryant, 2003; Hagen & Hammerstein, 2009) hypothesized that the enactment of intentionally synchronized behavior initially evolved as a means of signaling a coalition's fighting capacity; a subsidiary thesis holds that synchrony continues to index this property in agonistic contexts. Consonant with this perspective, in two studies, our U.S. Internet participants envisioned soldiers or terrorists as being more physically formidable – a representation that previous research indicates summarizes fighting capacity – when their audible footsteps were synchronized than when their footsteps were out of sync.

Importantly, in both studies, the increase in envisioned physical formidability accompanying synchrony was mediated by heightened perceptions that the synchronized individuals constitute a single unit, able to act effectively in concert in agonistic contexts. In contrast, although perceptions of affective bonding were enhanced by synchrony – thus conceptually replicating others' previous findings – the contribution of such perceptions to envisioned physical formidability were swamped by those of perceived entitativity. It thus appears that, to the extent that imputed sentiments are relevant to assessments of agonistic coalitional strength, this derives primarily from their connection to inferences regarding the degree of cohesion and coordination obtaining among the members of the given coalition. In short, those who move in sync do indeed signal that they can act effectively in concert in agonistic conflicts, and it is this efficacy – rather than rapport among the members – that drives assessments of their formidability.

We interpret these results as reflecting the functioning of a biologically evolved psychological mechanism that assesses synchronized behavior as an index of coalitional strength. However, because we surveyed American participants who are doubtlessly familiar with culturally-evolved practices of military drills and parades, we cannot rule out the possibility that our participants' estimates of the entitativity and formidability of the target individuals are in part the product of acquired cultural knowledge regarding the association between synchronized actions and martial skill. The use of synchronized behaviors as signals of coalitional strength in phylogenetically disparate species strongly suggests that, rather than being principally responsible for the patterns observed here, human cultural practices merely tap the affordances of evolved mechanisms. Nevertheless, given the limitations of our sample, a definitive answer to this question must await attempts to replicate our findings among remote populations that lack a history of, and exposure to, the formal use of synchronization in military training, display, and practice.

In order to maximize the contrast between our two conditions, thereby providing the starkest test of the agonistic signaling hypothesis, we employed stimuli presenting behavior that was, respectively, either highly synchronized or highly out of sync. In reality, the coordinative capabilities and motivations that undergird both intentional synchrony and coalitional fighting capacity no doubt vary in a continuous rather than dichotomous fashion. Correspondingly, the agonistic signaling hypothesis predicts that observers should be able to differentiate with considerable precision between more- and less-synchronized behaviors, and should draw correspondingly graded distinctions as regards fighting capacity. Future investigations should therefore employ a wider range of stimuli with regard to the degree of synchrony evinced.

McNeill (1995) argued that the prominence of marching drills in contemporary military training despite the entirely obsolete nature of the tactics practiced therein stems from the enhanced cohesion and attendant motivations that such practices induce. Voluminous evidence supports the existence of the affective and cognitive responses that McNeill postulated, hence he is unquestionably correct as regards the transformative function of such training. However, marching drills are not limited to training exercises, but rather are a prominent feature of military displays. Our findings suggest that, consonant with Hagen and colleagues' thesis regarding the signaling functions of synchronized behavior, in military parades around the world, missiles and tanks are accompanied by marching soldiers because, despite the frequent irrelevance of the latter in conflicts involving the former, evolved psychological mechanisms lead observers to attend to synchrony as a key constituent of assessments of formidability. More broadly, displays of synchronized behavior play central roles in a wide range of activities. Particularly when they occur in competitive contexts such as sporting events (which are reasonably understood as proxies for coalitional agonistic conflict [Fessler & Haley, 2003; Winegard & Deaner, 2010]), these displays plausibly tap the same signaling system as that explored here, and can thus be understood as cultural exaptations that exploit psychological mechanisms whose proper domain is violent intergroup conflict.

## **Notes**

1. Decomposing the composite physical formidability measure, follow-up tests revealed that the mean individual ratings of target height, muscularity, and overall size were all significantly greater in the Synchrony condition (see ESM Table S3).

2. The correlations between the three outcome measures remain significant ( $ps < .001$ ) and of approximately the same magnitude ( $rs .20 - .52$ ) if the Synchrony and/or Framing conditions are controlled for.
3. Decomposing the composite physical formidability measure in Study 2, follow-up tests revealed that, as in Study 1, the mean individual ratings of target height, muscularity, and overall size were all significantly greater in the Synchrony condition (see ESM Table S8) These differences are magnified if Framing is not included as a covariate.
4. The correlations between the three outcome measures in Study 2 remain significant ( $ps < .001$ ) and of approximately the same magnitude ( $rs .20 - .62$ ) if the Synchrony and/or Framing conditions are controlled for.

### **Acknowledgments**

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**Online Supplemental Material  
to accompany**

**Synchronized Behavior Increases Assessments of the Formidability and Cohesion of  
Coalitions**

- Stimuli Creation
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- Entitativity Measure
- Bonding Measure
- Figure S1 Visual Dependent Measure Arrays
- Effects of Condition and Participant Sex on Perceived Threat of Terrorism
- Tables
  - *Table S1*: Mean Effect of Target Framing on Estimated Physical Formidability, Entitativity, and Bonding (Study 1)
  - *Table S2*: Mean Effect of Participant Sex on Estimated Physical Formidability, Entitativity, and Bonding (Study 1)
  - *Table S3*: Mean Effect of Synchrony on Estimated Height, Muscularity, and Size (Study 1)
  - *Table S4*: Mean Effect of Target Framing on Estimated Threat of Terrorism (Study 1)
  - *Table S5*: Mean Effect of Participant Sex on Estimated Threat of Terrorism (Study 1)
  - *Table S6*: Mean Effect of Target Framing on Estimated Physical Formidability, Entitativity, and Bonding (Study 2)
  - *Table S7*: Mean Effect of Participant Sex on Estimated Physical Formidability, Entitativity, and Bonding (Study 2)
  - *Table S8*: Mean Effect of Synchrony on Estimated Height, Muscularity, and Size (Study 2)
- References

## Stimuli Creation

The stimuli employed in this experiment are available as Electronic Supplementary Material at the publisher's website. A recording of a single man walking was downloaded from <http://www.audiomicro.com/man-walking-human-person-man-walking-free-sound-effects-41721> and edited to produce 18 distinct footfalls. In order to convey the presence of a second unique individual while maintaining the acoustic features of the original recording, we next duplicated this recording and, using our subjective perceptions as a guide, rearranged the order of the 18 individual footfalls contained therein, such that comparing the two recordings gives the impression of two individuals whose walking patterns are similar to one another but not identical. The synchronous stimuli were then created by playing the original recording and the modified recording, maximally spatially displaced in stereo, with near-complete overlap in phase (a very slight phase displacement is necessary in order to make the two recordings distinguishable from one another, thus giving the impression of two separate individuals). Using the same two recordings, again maximally spatially displaced in stereo, the asynchronous stimuli were created by both increasing the degree to which the two tracks are out of phase and altering the intervals between footsteps, making these modifications in such a manner as to preserve realism in our subjective assessment. The latter procedure ensures that the two tracks are not perfectly out of phase, as prior research indicates that perfectly out-of-phase behaviors have similar, albeit reduced, effects relative to perfectly in-phase behaviors (see Miles et al. [2009] for discussion of the relevance of this distinction). Finally, we played the recordings for a group of 25 UCLA undergraduates, asking them how many individuals were in each recording, and whether the individuals in each recording were walking in synch or out of synch. The listeners

overwhelmingly affirmed that the stimuli produced the desired effect, uniformly reporting that two distinct individuals were audible in both recordings, and that in one recording the two individuals were walking in synch, while in the other recording they were not. The stimuli themselves are archived as part of this electronic supplement; readers interested in the recordings' precise attributes can conduct desired measurements directly on them.

## Target Framing Text

*On the page prior to hearing the audio clip, participants read:*

The sound that you will hear on the next page was taken from a video recording of two [American soldiers / terrorists] [*Study 1*: marching; *Study 2*: on patrol].

Please listen closely.

The sound will begin automatically. (It may take a few moments to load.)

Please only listen once.

Please make sure to remove any distractions before continuing.

*Next, on the page presenting the audio clip, participants read:*

Listen closely and mentally picture the two [soldiers / terrorists].

When playback is finished, please go to the next page.

(If the sound has not begun after 30 seconds, please reload the page.)

*On the following page, participants read:*

Please hold your mental picture of the men you heard in mind, as vividly as you can.

Answer the following questions based on the way that you envision them.

### Entitativity Measure

*Please rate how much you agree with the following statements about the men:*

- I have the feeling the men can work together.\*
- I feel these men would be dangerous if they teamed together in battle.
- I feel the men are a unit.\*
- I feel these men can communicate with each other in a battle or an attack.
- I feel these men are like one.\*
- I feel these men would be able to coordinate with each other to carry out an attack.

These statements were rated according to a 7-point rating scale (1 = *Not at all*; 7 = *Extremely*).

\* Modified from Postmes, Brooke, and Jetten (n.d.), as presented in Lakens and Stel (2011).

### **Bonding Measure**

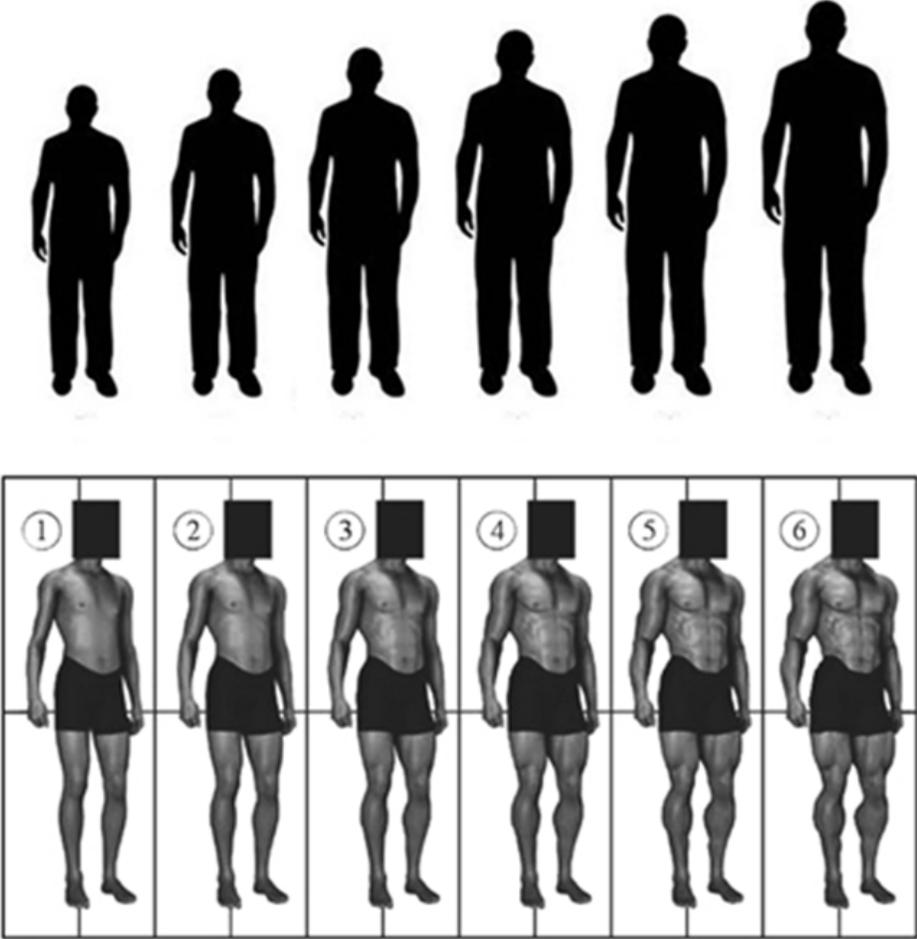
- How long do you think these men have known each other?  
(1 = *A very short time*; 8 = *A very long time*)
- How much do you think these men like each other?  
(1 = *Very little*; 8 = *Very much*)
- How willing do you think these men are to help each other?  
(1 = *Very little*; 8 = *Very much*)
- How likely is it that these men grew up together?  
(1 = *Very unlikely*; 8 = *Very likely*)
- How likely is it that these men will be friends 5 years from now?  
(1 = *Very unlikely*; 8 = *Very likely*)
- In an emergency, how effective could these men be?  
(1 = *Not at all effective*; 8 = *Very effective*)
- How likely are these men to argue with each other?\*

(1 = *Very unlikely*; 8 = *Very likely*)

\* Reverse scored

Modified from Hagen and Bryant (2003).

Figure 1. Top: Array used by participants to estimate overall size. Bottom: Array used by participants to estimate muscularity. Modified with permission from Frederick & Peplau (2007).



### **Effects of Condition and Participant Sex on Perceived Threat of Terrorism**

Following the primary dependent measures, during the demographic survey, participants were asked two exploratory questions probing the perceived threat of terrorism (“How much of a threat do you feel that terrorists pose to you or your loved ones?”; “How much of a threat do you feel that terrorists pose to the world?”), rated on a 7-point scale (1 = *None at all*; 4 = *Moderate*; 7 = *Extreme*).

We observed no effects of Synchrony condition or interactions between Synchrony and target Framing on responses to either terrorism question,  $ps > .57$ . However, there was a significant main effect of target Framing condition on responses to both questions. Participants who had been told that the marching sounds were produced by terrorists rated the threat of terrorism to be greater than did participants who were told that the sounds were produced by U.S. soldiers, presumably because the terrorist framing increased the salience of the threat of terrorism (see Table S4).

We next assessed potential sex differences in perceptions of the threat of terrorism. Female participants produced greater ratings in response to both questions relative to male participants (see Table S5), with no interactions between sex and Synchrony condition ( $ps > .49$ ) or target Framing condition ( $ps > .06$ )

Table S1

*Mean Effect of Target Framing on Estimated Physical Formidability, Entitativity, and Bonding (Study 1)*

	U.S. Soldier	Terrorist	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
	<i>Mean (SD)</i>	<i>Mean (SD)</i>				
Physical Formidability	.30 (.70)	-.25 (.80)	89.03	<.001	.11	-.65, -.43
Entitativity	5.73 (1.03)	5.33 (1.16)	22.69	<.001	.03	-.56, -.23
Bonding	5.22 (.85)	4.72 (1.25)	35.81	<.001	.05	-.66, -.33

Note. *N* = 698. Mean physical formidability scores reflect standardized variables (z-scores).

Table S2

*Mean Effect of Participant Sex on Estimated Physical Formidability, Entitativity, and Bonding  
(Study 1)*

	Female	Male	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
	<i>Mean (SD)</i>	<i>Mean (SD)</i>				
Physical Formidability	.08 (.76)	-.08 (.83)	7.70	<.01	.01	.05, .29
Entitativity	5.64 (1.09)	5.38 (1.13)	9.49	<.01	.01	.09, .42
Bonding	4.98 (1.15)	4.92 (1.08)	.42	.516	.00	-.11, .22

Note. *N* = 698. Mean physical formidability scores reflect standardized variables (z-scores).

Table S3

*Mean Effect of Synchrony on Estimated Height, Muscularity, and Size (Study 1)*

	Asynchronous	Synchronous				
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
Height (in.)	71.58 (2.27)	71.97 (2.35)	5.04	.025	.01	-.74, -.05
Muscularity	2.75 (1.08)	3.04 (1.03)	13.02	<.001	.02	-.45, -.13
Size	4.24 (.93)	4.53 (.90)	17.37	<.001	.02	-.42, -.15

Note.  $N = 698$ .

Table S4

*Mean Effect of Target Framing on Estimated Threat of Terrorism (Study 1)*


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	U.S. Soldier	Terrorist				
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
Threat to self / loved ones	3.35 (1.63)	3.96 (1.90)	20.19	<.001	.13	.34, .87
Threat to the world	4.99 (1.61)	5.29 (1.51)	6.11	.014	.01	.06, .53

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Note.  $N = 698$ .

Table S5

*Mean Effect of Participant Sex on Estimated Threat of Terrorism (Study 1)*


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	Female	Male	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
	<i>Mean (SD)</i>	<i>Mean (SD)</i>				
Threat to self / loved ones	4.16 (1.75)	3.19 (1.73)	54.23	<.001	.07	.71, 1.23
Threat to the world	5.56 (1.38)	4.74 (1.63)	50.66	<.001	.07	.59, 1.04

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Note. *N* = 698.

Table S6

*Mean Effect of Target Framing on Estimated Physical Formidability, Entitativity, and Bonding (Study 2)*

	U.S. Soldier	Terrorist				
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>F</i>	<i>p</i>	$\eta^2_p$	95% CI
Physical Formidability	.27 (.63)	-.29 (.83)	77.68	<.001	.13	-.69, -.44
Entitativity	5.73 (1.00)	5.23 (1.20)	27.74	<.001	.05	-.69, -.32
Bonding	5.21 (.90)	4.68 (1.25)	31.73	<.001	.06	-.71, -.34

Note.  $N = 534$ . Mean physical formidability scores reflect standardized variables (z-scores).

Table S7

*Mean Effect of Participant Sex on Estimated Physical Formidability, Entitativity, and Bonding  
(Study 2)*

	Female	Male				
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>F</i>	<i>p</i>	$\eta^2_p$	95% CI
Physical Formidability	.11 (.79)	-.10 (.77)	11.35	.001	.02	.09, .34
Entitativity	5.58 (1.10)	5.40 (1.15)	4.00	.046	.01	.00, .38
Bonding	5.00 (1.15)	4.91 (1.08)	.92	.338	.00	-.09, .28

Note.  $N = 534$ . Mean physical formidability scores reflect standardized variables (z-scores).

Analyses control for target Framing condition.

Table S8

*Mean Effect of Synchrony on Estimated Height, Muscularity, and Size (Study 2)*

	Asynchronous	Synchronous				
	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>F</i>	<i>P</i>	$\eta^2_p$	95% CI
Height (in.)	71.47 (2.17)	71.96 (2.21)	4.94	.027	.01	-.77, -.05
Muscularity	2.78 (.91)	2.99 (.97)	4.56	.033	.01	-.32, -.01
Size	4.25 (.89)	4.47 (.90)	5.87	.016	.01	-.33, -.03

Note.  $N = 534$ . Analyses control for target Framing condition.

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