

Quantifying collective effervescence

Heart-rate dynamics at a fire-walking ritual

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Collective rituals are ubiquitous and resilient features of all known human cultures. They are also functionally opaque, costly, and sometimes dangerous. Social scientists have speculated that such rituals generate benefits in excess of their costs by reinforcing social bonding and group solidarity, yet quantitative evidence for these conjectures is scarce. Our recent study measured the physiological effects of a highly arousing Spanish fire-walking ritual, revealing shared patterns in heart-rate dynamics between participants and related spectators. We briefly describe our results, and consider their implications.

Collective rituals are a puzzling aspect of human behavior. They are ubiquitous, resilient, and evoke powerful emotions and commitments, yet they are functionally opaque and lack straightforward payoffs.¹ This evolutionary cost problem²⁻⁴ is particularly evident among highly stressful rituals, which often tempt bodily harm. Social scientists have long speculated that collective rituals generate benefits exceeding their costs by reinforcing social bonding and group solidarity.^{5,6} Famously, Emile Durkheim proposed the notion of “collective effervescence,”⁷ a feeling of belonging and assimilation produced by collective ritual action. Yet, there is little numerical evidence for this conjecture.⁸ More generally, the mechanisms that drive solidarity effects remain unclear. Two hypotheses about mediating mechanisms stand out: according to a “coordinated movement” hypothesis (H1), it is the harmonization

of movements that aligns the cognitive and affective states of participants, evoking heightened solidarity.⁹⁻¹² According to an “empathetic projection” hypothesis (H2), it is the imagined responses of participants to focal events of the ritual that align their relevant cognitive states, without any strict need for orchestrated motor coordination.¹³⁻¹⁵ While H1 and H2 are compatible, and indeed such effects may interact,⁹ the relative importance of movement and empathy for naturally occurring rituals remains an open question.

In a recent study of a highly arousing fire-walking ritual,¹⁶ we quantified shared patterns in heart-rate dynamics between fire-walkers and spectators during the event to examine whether these effects would be mediated by partaking of the same ordeal and prior social affiliation. The study was conducted in the Spanish village of San Pedro Manrique, where a fire-walking ceremony takes place annually as part of the festival of San Juan. This ceremony is the biggest event in the area, performed in a specially constructed venue with a capacity of 3,000 people, five times the local population. At the climax of the ceremony, a few dozen locals take their place at the center of the venue, and one by one cross a bed of glowing coals, carrying a beloved one on their backs (Fig. 2). Although the ritual is not explicitly religious, it carries tremendous importance for the locals.

Hypothesizing that synchronous arousal would be detectable in certain physiological states of ritual participants, we measured the heart rates of performers and spectators during the ceremony.

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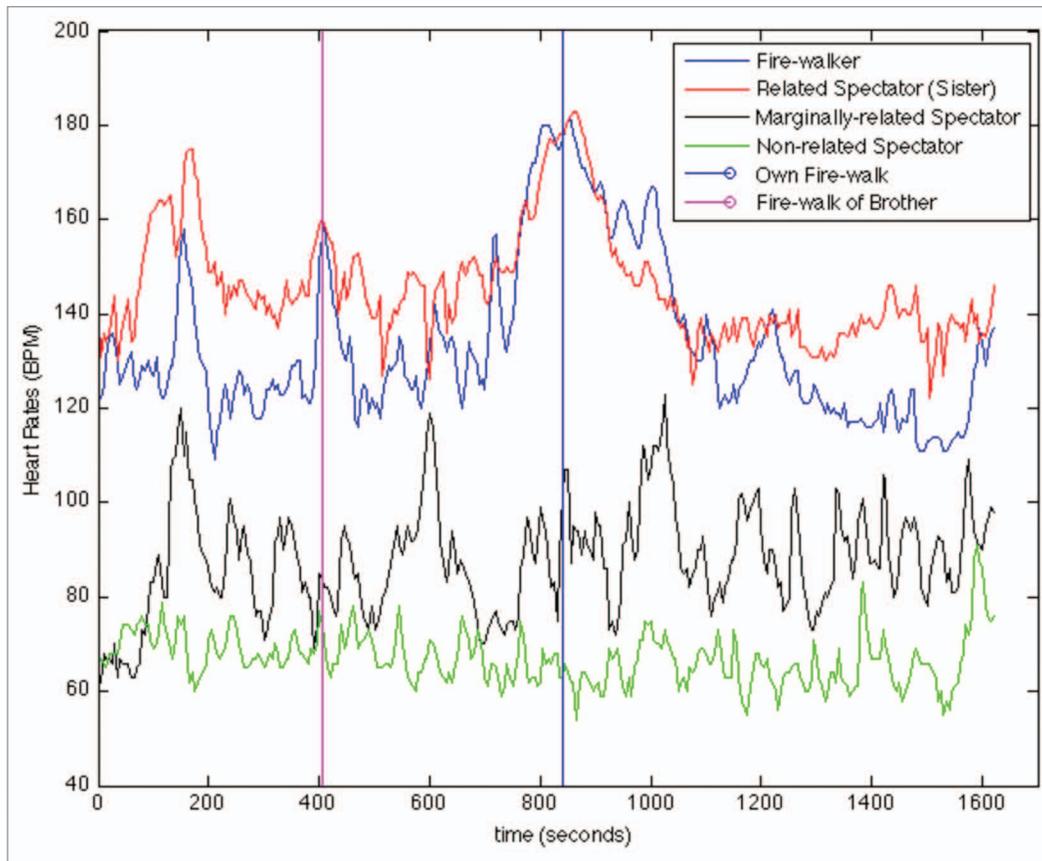


Figure 1. Heart-rates (in beats per minute) during the ritual from a representative fire-walker (blue), related sister-spectator (red), marginally related spectator (related to another fire-walker, black), and non-related spectator (green). The blue and pink vertical lines mark the time the fire-walker and his brother cross the fire, respectively.

Based on our hypothesis that empathetic arousal is one mechanism that facilitates social bonding (H2), we expected to find shared arousal among fire-walkers as well as between fire-walkers and spectators, even though the latter merely witnessed without performing the key ritual action sequences. We obtained data from twelve fire-walkers, nine spectators who were either relatives or friends of at least one fire-walker (“related spectators”), and 17 unrelated visitors-spectators. Data were analyzed for two source epochs, the entire 30 min duration of the fire-walk, and a 30 min baseline recorded a few hours before the ritual, using recurrence quantification analysis (RQA) on individual data, and cross-recurrence quantification analysis (CRQA) on paired participants’ data.

For intra-personal effects, recurrence plots¹⁷ revealed global similarities between fire-walkers and related spectators, but not unrelated spectators. For quantification,

four RQA measures were compared (%DETerminism, MAXLine, Entropy, Laminarity) using a 3×2 mixed model MANOVA, with the group as a between-subject variable, and the source epoch (ritual vs. baseline) as a within-subjects variable. The analysis yielded a significant main effect of the group [$F(8,64) = 2.75, p < 0.011$], a significant interaction [$F(8,64) = 3.869, p < 0.001$], but only a marginal effect of the source epoch ($p = 0.077$). Post-hoc (Bonferroni correction) analyses revealed differences between fire-walkers and nonrelated spectators, but did not distinguish fire-walkers from related spectators (only in stability, i.e., MAXLine).

Inter-personal effects were investigated using CRQA, a bivariate extension of RQA.¹⁸ The four key measures were compared using a similar design, with relatedness as the between-subjects variable, and the source epoch as the within-subjects variable. The MANOVA yielded a main effect of relatedness [$F(8,24) =$

$3.508, p < 0.008$], a main effect of the ritual [$F(4,12) = 9.473, p < 0.001$], and a marginal interaction, $p = 0.079$. Post-hoc tests revealed no differences between the related and marginally related pairs, but showed lower shared dynamics with the unrelated pairs.

Importantly, our data indicate that ritual effects are more intricate and subtle than suggested by the qualitative concept of “collective effervescence.” Specifically, the analysis revealed a strong alignment among the heart rates of fire-walkers and related spectators, showing an associative empathetic response, which operates irrespectively of personal activity and experience of fire-walking, thus supporting H2. This response, however, did not extend to non-related spectators, indicating that patterns of arousal are not merely driven by the individualistic qualities of the ritual, but are also subjectively, socially and emotionally mediated in response to the performances of others. Remarkably,



Figure 2. Fire-walkers go through their ordeal carrying a beloved one at their back.

spectators who were related to at least one fire-walker exhibited shared patterns of arousal also to fire-walkers they were not closely related to. This suggests that the ritual extends a boundary of empathetic concern with network-like effects, from related to unrelated performers.

Finally, our data indicate that merely observing a ritual may be insufficient to produce collective emotions of the kind and/or degree experienced by the performers and their supporters. Shared arousal between performers and spectators was discovered only for those spectators who previously identified with at least one fire-walker, with levels of sharing predicted by prior association, and for those with the strongest responses, by participation in the central ritual ordeal. (Fig. 1).

While no study could hope to explain more than a small fraction of something so complex as a collective ritual, our investigation revealed levels of intricacy and refinement unavailable to qualitative

ethnography. Far from being antagonistic to cultural anthropology, quantitative field experiments suggest the prospect for unprecedented power in the detection of sociocultural signals that remain elusive to classical methodologies.

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