Neuroscience and Biobehavioral Reviews 161 (2024) 105639

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

# Human expressive movements: The boundary between health and disease from a contaminated perspective

Angelo Pascarella [a,b,1], Sara Gasparini [a,b,1], Angela Bellia [c], Enrico Bertolotti [d], Benedetta Bessi [e], Gaetano Cantalupo [f,g], Diego Centonze [h], Vittoria Cianci [b], Cesare M. Cornaggia [i], Felice Costabile [j], Antonio Gambardella [a], Angelo Labate [k], Carmelo Malacrino [l], Adriana Magaudda [m], Marco Mula [n], Francesco Paladin [o], Giovanni Pizza [p], Carlo Alberto Tassinari [f,q], Elisa Vermiglio [r], Edoardo Ferlazzo [a,b], Umberto Aguglia [a,b,*]

[a] Department of Medical and Surgical Sciences, Magna Grœcia University of Catanzaro, Italy
[b] Great Metropolitan "Bianchi-Melacrino-Morelli Hospital", Reggio Calabria, Italy
[c] National Research Council, Neaples, Italy
[d] Architect, freelancer, Theater Director, Venice, Italy
[e] Ca' Foscari" University, Venice, Italy
[f] Center for Research on Epilepsy in Pediatric age (CREP), Child Neuropsychiatry Unit, University Hospital of Verona, Italy
[g] Innovation Biomedicine section, Department of Engineering for Innovation Medicine, University of Verona, Italy
[h] Department of Systems Medicine, Laboratory of Synaptic Immunopathology, "Tor Vergata" University, Roma, Italy
[i] School of Medicine and Surgery, University of Milano Bicocca, Milan, Italy
[j] Mediterranean University of Reggio Calabria, Italy
[k] Neurophysiopathology and Movement Disorders Clinic, University of Messina, Italy
[l] National Archeologic Museum Reggio Calabria, Italy
[m] Department of Clinical and Experimental Medicine, University of Messina, Italy
[n] IMBE, St George's University and the Atkinson Morley Regional Neuroscience Centre, St George's University Hospital, London, UK
[o] Venice International University, Isola di San Servolo, Venice, Italy
[p] Department of Philosophy, Social Sciences and Education, Perugia University, Perugia, Italy
[q] Department of Biomedical and Neuromotor Sciences, Alma Mater Studiorum University, Bologna, Italy
[r] Department of Education and Social Services of the Mediterranean Area, Dante Alighieri University, Reggio Calabria, Italy

ARTICLE INFO

*Keywords:*
Central pattern generators
Choreomania
Functional neurological disorders
Mass hysteria
Psychogenic non-epileptic seizures

Expressive movements represent forms of non-verbal communication by means of gestures, postures, and body expressions. They are a fundamental aspect of human communication, enriching and expanding the meaning of spoken words (Niedenthal, 2007). Expressive movements are a highly coordinated and creative form of motor behavior, generated by a common anatomical-functional substrate, particularly the Central Pattern Generators (CPGs) able to produce complex, rhythmic, innate patterns. The activity of CPGs is modulated by sensory input and signals from higher brain regions (Yuste et al., 2005), including the limbic system, which is involved in emotions processing. Participation in collective mystical-religious rituals and dance are powerful inducers of complex motor activities with high emotional impact. Notably, some brain diseases can result in uncontrolled actions and movements with high expressive contents. Epileptic seizures

* Correspondence to: Department of Medical and Surgical Sciences, Magna Grœcia University of Catanzaro, Italy; Regional Epilepsy Centre, "Bianchi-Melacrino-Morelli" Great Metropolitan Hospital, Reggio Calabria, Italy.
*E-mail address:* u.aguglia@unicz.it (U. Aguglia).
[1] These authors share equal contribution.

https://doi.org/10.1016/j.neubiorev.2024.105639
Received 27 January 2024; Received in revised form 6 March 2024; Accepted 20 March 2024
Available online 28 March 2024

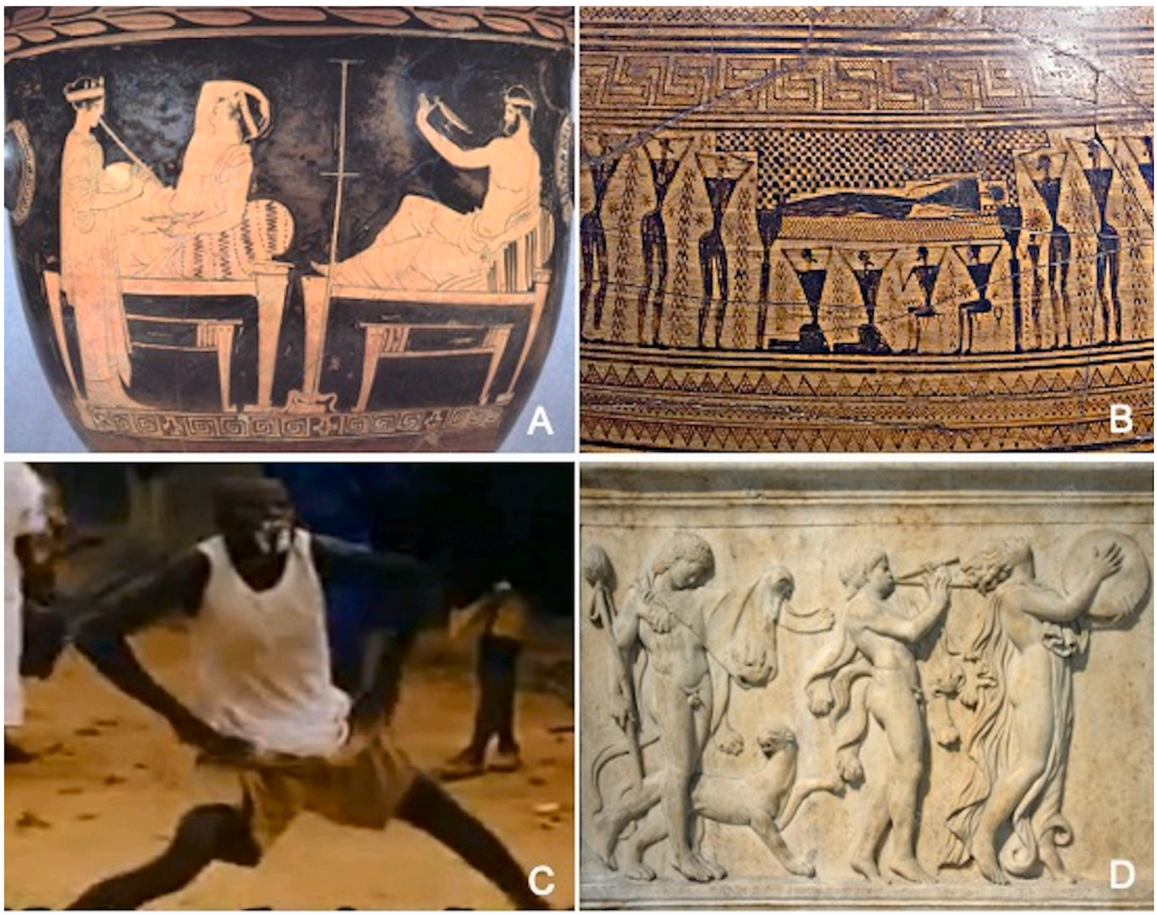


**Fig. 1. Harmonies of movement: amid melodic enchantment, funeral laments, shamanic rituals and Bacchic ecstasy. (A)** Agrigento (ancient Akragas). Archaeological Museum "Pietro Griffo", Inv. AG. 1582. 425–420 BCE; **(B)** Dipylon Amphora, Archaeological Museum of Athens, 804, approximately 760–750 B.C., Dipylon Master, photo by Paolo Villa. CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0/deed.en>, from Wikimedia Commons; **(C)** Les maîtres fous (The Mad Masters) by Jean Rouch France, 1954; **(D)** Dionysus (Roman Bacchus), a Satyr and Bacchante form a procession. Roman c.100 British Museum.

represent a well-known example. Depending on the cortical area involved, ictal motor manifestations may assume various and peculiar forms, sometimes resembling physiological, voluntary, human expressive movements, such as spitting, laughter, and dancing. Notably, expressive movements may also occur in functional neurological disorders (FND), such as Psychogenic Non-Epileptic Seizures (PNES) and a wide spectrum of other movements disorders. FND are characterized by changes in motor, sensory, or cognitive functioning and exhibit one or more deficit patterns primarily indicative of nervous system dysfunction. The interpretation of expressive movements either as pathological or cultural phenomena can vary depending on historical, socio-cultural, and individual context. This theme represents the main objective of this paper and it was discussed in a conference titled "Expressive Actions and Movements in Rite, Art and Illness" held in Reggio Calabria (Italy) in June 2023, featuring contributions from neurologists, psychiatrists, anthropologists, historians, archaeologists, and choreographers (see Supplementary material).

The expressive movements share similar features in humans across different historical, geographical, cultural and clinical contexts. Some elementary expressive movements (laughter, crying, courtship) are common to various animal species, suggesting ancient brain mechanisms' involvement. The complexity of human interactions allowed innate expressive movements to evolve from a level of communication of primal needs to more sophisticated motor patterns embedded in a wide range of socially relevant behaviors. Expressive movements can be codified, as happens in ceremonies (e.g. rites) and artistic oeuvres (e.g. dance), or conversely uncodified (e.g. tarantism). Dance and theater are prominent expression of non-verbal language where movements are encoded into sequences of structured and predefined gestures. The relationship between music and expressive movements is also profound. Even in ancient Greek culture, the power of music to inspire and guide a wide range of body movements reflecting emotions, moods, and intentions, was well-known (Fig. 1A). Mankind's innate ability to perceive musical rhythm suggests the existence of auditory-motor neural networks involving cognitive, emotional and expressive processes. Codified movements and chants in funeral dirge enable participants to engage in grief, generating an atmosphere of collective mourning and sadness (Fig. 1B) (De Martino, 1958). Codified movements in religious rituals play a fundamental role in creating a shared spiritual experience during worship and religious ceremonies. For instance, the shamans may use dances, ritual gestures and specific body movements (Fig. 1C) to heal diseases. Uncodified movements may consist of disordered, frenzied or violent limb movements, loss of muscle tone, falling to the ground, facial expressions of fear or crying, or even staring with apparent loss of consciousness. The attempts to comprehend the significance of expressive movements is challenging in humans, as it may be very difficult to understand whether they represent expressions of psychological and social distress or rituals with therapeutic effects (Lanska, 2018). Tarantism, a historical cultural phenomenon diffused in southern Italy from the Middle Ages to the mid-20th century, represents an impressive example of continuum between illness and cure. It refers to a condition where individuals (predominantly females) believed they had been bitten by a "tarantula spider" and experienced symptoms such as restlessness, anxiety, and uncontrollable dancing; simultaneously, this

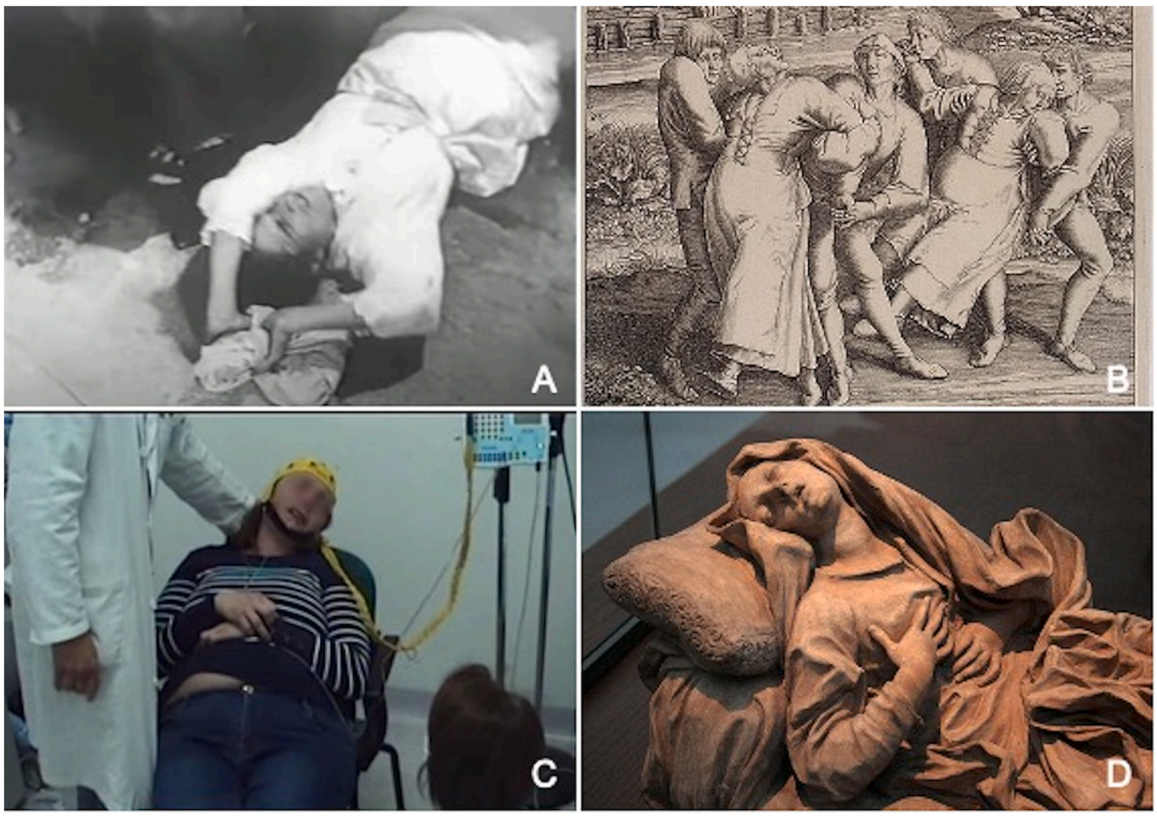


**Fig. 2. Dynamics of expression: movements, dance, illness, and rite. (A)** Tarantata Woman, from «la Taranta», directed by G.F. Mingozzi, consultancy E. De Martino, https://www.youtube.com/watch?v=PTi_hAdwsR0; **(B)** Dancing Plague of 1518, engraving by H. Hondius from Pieter Brueghel's drawing of 1564. Hendrik Hondius I, Public domain, via Wikimedia Commons; **(C)** Patient with functional seizure, video acquired at Regional Epilepsy Centre, Great Metropolitan Hospital, Reggio Calabria (Italy), informed consent signed by patient; **(D)** Ecstasy of the Blessed Ludovica Albertoni, Jean-Pol GRANDMONT, Louvre. Jean-Pol GRANDMONT, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, from Wikimedia Commons.

dancing (Fig. 2A) was considered a form of cure, as it was believed to expel the spider's venom (De Martino, 1961). "Bacchic frenzy" and "choreomania" represent striking examples of uncodified expressive movements that lie along a continuum between illness and cultural phenomenon. "Bacchic frenzy" (Fig. 1D) denotes a state of intense emotional and physical excitement, often associated with excessive indulgence in drinking, revelry and uninhibited behavior, due to ecstatic possession by Bacchus, the God of wine. The unrestrained dances accompanying collective rituals since ancient Greece may be interpreted as the urge to transcend the rigid conventions of society through a liberating loss of control. The higher participation of females in these rituals may be attributed to social constraints that historically restricted women's opportunities for self-expression. The convergence of social, cultural, and psychological dynamics is also evident in "choreomania" (Fig. 2B) and other forms of "mass psychogenic illness". "Choreomania" is characterized by uncontrollable and spontaneous dancing or rhythmic movements in a group of individuals who start dancing or moving in an uncoordinated manner, often as a response to psychological distress (Lanska, 2018). The origin of this phenomenon is linked to post-pagan rituals, but Christian restrictions on customs in medieval Continental Europe might have contributed to the reactive nature of these phenomena. Starting as spontaneous and loosely structured, as the phenomenon spreads and more individuals become involved, a 'modeling' effect emerges, leading to increasing organization (such as the arrangement of stages and orchestras seen during the dancing epidemic in Strasbourg), thereby acquiring distinct social significance. Ultimately, the distinction between "normality" and "illness" or "illness" and its "treatment" depends on historical and social context, voluntariness, and the impacts on the individual, his/her family, and lastly, society.

The expressive movements observed in tarantism or "choreomania" are strikingly similar to those observed in hypermotor epileptic seizures, parasomnias (Tassinari et al., 2005), hypermotor "functional seizures" and agitated catatonia. Complex motor behavior and gestural signs, such as facial expression, rhythmic limb, trunk and pelvic movements, and jumping strictly resembling a "dance", characterize the fascinating ictal semiology of the dancing seizures. Burst of unmotivated, uncontrolled, stereotyped, laughter unprovoked by external stimuli constitute the ictal features of gelastic seizures. Apparent loss of awareness, absence of movement, assumption of fixed postures, and an upward gaze, characterize functional "dialeptic" seizures, "retarded" catatonia as well as the trance associated with mystical ecstasy (Fig. 2C-D). Evidence about brain network dysfunctions is available for epileptic seizures, parasomnias, and FND. The activation of CPGs has been hypothesized (Tassinari et al., 2005) in parasomnias and in hypermotor seizures. Functional neuroimaging studies in individuals with FND (Baizabal-Carvallo et al., 2019) have revealed abnormal increases in connectivity between limbic and motor systems, along with alterations in cortical regions responsible for movement planning, self-awareness, interoception, and emotional processing. Whether these same brain networks contribute to conditions like "choreomania" or tarantism is still unknown.

An in-depth understanding of the relationship between expressive movements and functional disorders calls for a comprehensive, multidisciplinary approach that harmonizes knowledge from neurobiology with the ongoing evolution of socio-cultural influences.

## Declaration of Competing Interest

The authors declare that they have no relevant financial or non-financial interests to disclose that are relevant to the content of this

article.

## Acknowledgement

Work supported by #NEXTGENERATIONEU (NGEU) and funded by the Ministry of University and Research (MUR), National Recovery and Resilience Plan (NRRP), project MNESYS (PE0000006) – A Multiscale integrated approach to the study of the nervous system in health and disease (DN. 1553 11.10.2022).

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2024.105639.

## References

Baizabal-Carvallo, J.F., Hallett, M., Jankovic, J., 2019. Pathogenesis and pathophysiology of functional (psychogenic) movement disorders. Neurobiol. Dis. 127, 32–44. https://doi.org/10.1016/j.nbd.2019.02.013.

De Martino E. 1961. La terra del rimorso. Contributo a una storia religiosa del Sud. Il Saggiatore. Milano.

Lanska, D.J., 2018. The dancing manias: psychogenic illness as a social phenomenon. Front Neurol. Neurosci. 42, 132–141. https://doi.org/10.1159/000475719.

Niedenthal, P.M., 2007. Embodying emotion. Science 316, 1002–1005. https://doi.org/10.1126/science.1136930.

Tassinari, C.A., Rubboli, G., Gardella, E., Cantalupo, G., Calandra-Buonaura, G., Vedovello, M., Alessandria, M., Gandini, G., Cinotti, S., Zamponi, N., Meletti, S., 2005. Central pattern generators for a common semiology in fronto-limbic seizures and in parasomnias. A neuroethologic approach. Neurol. Sci. 26 (Suppl 3), s225–s232. https://doi.org/10.1007/s10072-005-0492-8.

Yuste, R., MacLean, J.N., Smith, J., Lansner, A., 2005. The cortex as a central pattern generator. Nat. Rev. Neurosci. 6, 477 doi: 10.1038/nrn1686.