Title:

Solvitur Ambulando: Why Humans Walk Extraordinary Distances Together Serving Abstract Ends

Shane O'Mara, School of Psychology and Institute of Neuroscience, Trinity College, Dublin – the University of Dublin, College Green, D02 PN40, Ireland

brainpizza.substack.com

Correspondence: shane.omara@tcd.ie

Abstract

Human walking is a socially-embedded and shaped biological adaptation: it frees our hands, make our minds mobile and is deeply health-promoting. Yet, today, physical inactivity is an unsolved, major public health problem. However, globally, tens of millions of people annually undertake ancient, significant, and enduring traditions of physiologically- and psychologically-arduous walks (pilgrimages) of days-to-weeks extent. Pilgrim walking is celebrated, discussed, and analysed in important literary, historical, and religious works as a defining human activity: one requiring weighty commitments of time, action, and belief, as well as community support. Paradoxically, human walking is most studied on treadmills, not '*in the wild*'. While mechanistically vital, treadmill studies of walking cannot, in principle, address why humans walk extraordinary distances together for abstract ends, or provide the means to bring much-needed physical activity back into our everyday lives.

Pilgrim walkers provide a rich 'living laboratory' bridging literary, historical, and religious inquiries, to progressive theoretical and empirical investigations of human walking serving abstract ends. Pilgrims offer advantages for causal investigations: they vary demographically, and they undertake arduous journeys on precisely-mapped routes of tracked, titrated, doses and durations on terrain of varying difficulty, allowing controlled investigations from molecular to cultural levels of analysis. Here, using a novel, naturalistic, framework, we examine how pilgrim walking might shape personal, social, and transcendental processes, revealing potential mechanisms supporting the socially-embedded body and brain in motion, and beyond, to how pilgrim walking might offer some potential solutions for physical inactivity in society at large. (244 words)

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Introduction

Human walking is a socially-embedded and socially-moderated biological adaptation, conferring on us a singular upright posture, with a mobile head and eyes atop the spinal column¹. Bipedality frees our hands for gesture, tool use, food- and child-carrying, among myriad other functions. We humans have a remarkable range on foot; moreover, engaging in regular, sustained walking is profoundly health-promoting. Human walking serves more than mere locomotor functions, however. We humans walk together to demonstrate fidelity to an ideal; to source food we will share; for social display; to try and change the world; we walk together to find better lives for ourselves and for each other. At its core, our walking is profoundly social, and social walking is demonstrative: our walking with others signals to others our participation in shared intentions and collective goals. Furthermore, tens of millions of humans across the world regularly undertake walking journeys - pilgrimages - often of extraordinary lengths, in the service of abstract ends, at some personal and social cost to themselves. Our adaptations as bipedal walkers are, therefore, co-opted for social and other purposes extending far beyond simple individual locomotion. Here, we argue that, while relatively neglected theoretically and empirically, that pilgrim walkers comprise a 'living laboratory'; one bridging many literary, historical, and religious inquiries, to progressive theoretical and empirical investigations of these extended bouts of human walking undertaken to serve abstract ends. Pilgrim walkers offer advantages for causal and mechanistic investigations: they vary demographically, and they undertake arduous journeys on precisely-mapped routes of tracked, titrated, doses, and durations on terrain of varying difficulty, in groups of differing sizes with varying social support, differing belief systems, and differing levels of motivation, allowing controlled investigations from molecular-physiological to sociocultural levels of analysis. Situating pilgrim walking in a naturalistic, evolutionary and biopsychosocial context makes it a fruitful subject of empirical enquiry; furthermore, such investigations may offer implications for correcting some of the diseases arising from physical activity in many societies today.

Human walking and human dispersion

Humans travel about twice as far on foot, calorie for calorie, as our nearest primate relatives^{2,3}. From about 60kya-180kya^{4,5}, humans made multiple journeys out of Africa to the Eurasian landmass, eventually dispersing to the Americas and the greater Asia-Pacific region⁶, slowly populating the planet. This was a journey undertaken on foot, in migratory groups, in multiple waves, over thousands of years, populating the planet by walking together in migratory families, tribes and other groups, achieving global dispersion because of our adaptations as social walkers¹. Our remarkable geographical distribution makes us unlike any other species, for no other species has spread around the world in the promiscuous fashion we humans have. Selection effects binding individuals to their groups in the service of shared goals must have been paramount during these migratory walks of families, tribes and other groups^{7,8}; trace fossil evidence of human group migration supports this claim⁹, as do the forms of alloparenting and reproduction practiced in human groups^{10,11,12}. Shared goals might be day-to-day survival (food sourcing, avoiding predation, finding safe

shelter, and the like), or longer-term (such as migrating to places that humans had not been to before, and that are imagined to be better than current circumstances).

Walking and internal processes

Studies of human walking are dominated by laboratory treadmill studies¹³, with experiments largely focused on acute, rather than endurance, performance (e.g.,¹⁴); these are logistically easier, requiring only one or two short (~1-2 hr) laboratory visits. Long-term exercise studies are often conducted in small animal models (especially the rat: e.g.^{15, 16, 17}). These studies have been remarkably fruitful at revealing the spinal and other mechanisms supporting locomotion; changes entrained in body and brain by locomotion; and molecular, cellular and systems changes occurring because of locomotion. Walking involves the coordinated action of widespread brain regions supporting decision-making, goal-seeking, memory, and planning, and of motor and spinal regions responsible for motor pattern generation, and, eventually, of muscle groups (synergies)^{18, 19} entraining movement. In turn, movement feeds back on to brain and bodily function: for example, regular, daily bouts of brisk walking (at 70%–80% of predicted maximal heart rate) enhances cardiovascular health²⁰; furthermore, higher daily step counts are associated with substantially reduced all-cause mortality²¹, and aerobic fitness supports neurocognitive function throughout the life-course²².

Common neurocognitive substrates support cognitive mapping, memory, and imagination

Recent experiments confirm suggestions^{1, 23} that walking drives creative idea production and facilitates imaginative thinking^{24, 25, 23}. Opezzo and Schwartz²⁴ show short periods of corridor or treadmill walking approximately doubles creative idea production in a divergent thinking task, compared with a similar seated period; Kuo and Yeh²⁵ find a similar effect in aging adults, where a short period of walking approximately doubles their creative idea production, compared to young seated controls. The underlying neurocognitive mechanisms have not been fully delineated, but it is known that whole-body (locomotor) movement drives hippocampal formation activity to a remarkable degree (e.g.^{26, 27, 28}), probably via vestibular stimulation^{29, 30}, amplifying functions supported by the hippocampal formation (such as cognitive mapping and memory). People with amnesia arising from hippocampal damage have impoverished imaginations, mind-wandering and dreaming, while also being impaired in spatial orientation and navigation^{31, 32, 33}. Thus, the neurocognitive systems active during memory and imagination are also largely the same systems active during whole-body movement: in a remarkable theoretical and empirical convergence, cognitive mapping, memory, mental time travel, and imagination, share common neural substrates in the extended hippocampal formation^{34, 35, 36, 37, 38}. In turn, these processes are likely paced by theta rhythm (a low-frequency, 5-12Hz, rhythm present in the EEG of animals and humans^{39, 26}).

The '*default-mode*' of brain activity⁴⁰, occupies c.40% of our walking hours, involves mental time travel - coursing backwards and forwards through both the 'big picture' *and* the details of our lives, allowing us to construct our personal autobiographical narratives. 'Constructing narratives' about one's self and one's social world is a key function of default mode processing^{34, 41, 42}. Through narrative construction, we can, over time, integrate our experiential and remembering selves, forming a coherent, agentic, adaptive, identity. A

provocative hypothesis is that walking may affect autobiographical memory construction and recall. O'Mara¹ suggests regular and sustained walking facilitates the mental time travel central to creating personal narratives - constructing our autobiographical stories, and the meaning of the wider (social) world within which we live. Thus, walking, on this view, facilitates activity in the brain networks processing memory and meaning; in part, because whole-body locomotor movement activates the hippocampal formation and related structures, and, in part, because information sharing during social walking readily enters into our individual memories^{1, 43, 44}. Gibson & Nicholas⁴⁵, for example, find social walking assists in autobiographical narrative construction of shared experiences and the construction of tactile autobiographical memories in persons with dual sensory loss (congenital deaf-blindness).

Human walking is social

Remarkably, just hearing others walking activates brain networks supporting social cognition^{46, 47} emphasising how the mere sound of others' footfalls immediately enters social cognition. Walking with others makes demands on many brain and behavioural systems supporting the directed, coherent, movement of the group toward some – perhaps abstract or unknown – goal, and of group survival^{1, 48, 49}. Thus, we have brain systems and subsystems tuned to interpersonal synchronisation and pacing of walking movements^{50, 51}; wayfinding and cognitive mapping^{52, 36}; environmental vigilance and threat detection⁵³; goal orientation and achievement⁵⁴; shared social attention and gesture⁵⁵; tolerating uncertainty⁵⁶; optimism bias and risk-taking⁵⁷; memory and motivation^{58, 59, 60}; imagination⁶¹; and more. Walking with others, on this view, amplifies these processes through shared storytelling and interpersonal synchronisation during the movement of the group toward a common, and perhaps imagined, destination. This view suggests, therefore, that intrapersonal processes support interpersonal transactions with the environment⁶².

Human pilgrim walking

Annual pilgrimages are possibly the largest form of transient, human mass migrations⁶³: worldwide, Arcworld⁶⁴ estimate c. 155 M people annually engage in major pilgrimages⁶⁵, with an estimated 30 M pilgrims attending the *Ayyappan Saranam* festival in India (Hindu); and 20 M attending the *Our Lady of Guadalupe* pilgrimage (Christian) in Mexico. About c. 2.5 M attended the *Hajj* in Mecca in 2019⁶⁶. These pilgrimages involve combinations of substantial walking and mass transport, because individual vehicular travel is almost always impossible, given the density of people and lack of road space. Many hundreds of thousands annually walk the pilgrim walking trails in Europe (which run to a cumulative many thousands of kilometres in length). The most walked pilgrimage in Europe⁶⁷ is the *Camino de Santiago* in Galicia; the most popular route is the *Camino Francés* (780km: St Jean-Pied-du-Port, Biarritz to Santiago); the longest starts at Seville and is 1200km. Some 327,378 pilgrim walkers received the Pilgrim's Certificate (*Compostela*) from the Pilgrim's Office in 2019, an underestimate of the numbers walking these routes, as many do not claim the certificate, or walk for non-religious, secular, purposes^{68, 69}. These ancient traditions of physically- and psychologically-arduous pilgrimage walks are of days-to-weeks duration, and are undertaken for secular and/or religious reasons. Pilgrimages are a notable example of social walking, even when performed by a solitary pilgrim. Pilgrimages are performed in solidarity with a greater purpose – a community, a cause, a faith, demonstrating

the power of an ideal to animate a walking tribute to that ideal. Even the solitary pilgrim is walking for, and with, an imagined community of the mind. (**Note:** 'pilgrim walking' here embraces religious and secular walkers walking these ancient routes.)

Pilgrim walking as a literary, social, and contemporary phenomenon

The earliest recorded walking pilgrimages are found in various sites across the world, dating to >5-10kya^{70,71}. Pilgrimages are celebrated, discussed and analysed in numerous important literary, historical, and religious works. Geoffrey Chaucer's 14thC work, *'The Canterbury Tales'*, for example, concerns a pilgrimage from London to Canterbury; one character, the 'Wife of Bath' is described as 'wandr'ring by the Way', having undertaken what would have been very arduous pilgrimages to Jerusalem, Rome, 'Galice' (Galicia: Santiago di Compostela), Bologna and Cologne. Pilgrim walking is a metaphoric device in other works: in the *'Inferno'*, Dante the poet is also Dante the pilgrim, journeying the Circles of Hell; Bunyan's *'Pilgrim's Progress'*, is written as a dream sequence, where the pilgrim walks from the 'slough of despond' to the 'celestial city'. More recently, Cormac McCarthy's ash- and death-strewn novel, *'The Road'*, is a pilgrimage of necessity by the unnamed father and son, while 'carrying the fire', and walking the road to, perhaps, nowhere.

Pilgrim walking as a 'living laboratory'

Pilgrimage walking is empirically underexplored; interest most often focuses on anthropological, tourist economics, or crowd and leisure management aspects of pilgrimage⁷². In principle, PWs lend themselves to many controlled investigations: consider the possible effects of a 780km walk undertaken over 42 days (~18.5km/day). In principle, the physiometabolic effects of a such a walk can be investigated through testing factors in blood, measures of cardiac and aerobic fitness, and changes in visceral fat deposition. Similarly, changes in social interactions or social affiliation can, in principle be tested by measuring entrainment of interpersonal interactions with other members of the walking group (perhaps via experience sampling methodologies). Thus, pilgrim walkers can provide a fertile 'living laboratory', bridging literary, historical, and religious inquiries, to progressive theoretical and empirical investigations in a controlled 'model system', combining ease of investigation with generalisability. Pilgrim walkers (PWs) are many in number, easily accessible, and motivated. PWs are unusually homogenous with respect to intervention and experimental control: PWs undertake walks of titrated doses and durations (Camino walkers - up to 1200km/10 weeks), with metabolic demands requiring an approximate doubling of daily caloric intake⁷³. Moreover, walkers quickly adapt to extended walks, whereas runners take many months to train for single-occasion endurance events (such as marathons of 42.2 km/4-5hrs duration). PWs are a large and demographically-variable population running from c. 5ya to c. the late 80s, of various aerobic statuses and health conditions, with a marked representation of those in middle-age and above. Further, some PWs are persons with neurological conditions (e.g., stroke), other underlying health conditions (e.g. cardiovascular disease; diabetes; frailty), sensory or motor impairments (visual, auditory, etc.), neuropsychiatric conditions, mobility impairments requiring movement aids (walking sticks or crutches, prosthetic limbs, or all-terrain wheelchairs). PWs usually walk with family and friends, but some prefer lone walking. PWs undertake walks for secular (e.g., health; challenge; bucket list) and/or religious (e.g. penitential; obligatory) purposes. Some walk for 'self-healing' or

'self-therapy'^{74,75} (also a notable feature of walking groups practicing 'shared or communal therapeutic mobility'⁷⁶). Pilgrim routes are geospatially-mapped (and, via smartphone, digitally-tracked), of varying terrain and difficulty, testing individual differences in engagement, motivation and strain. Finally, while walking can be central to our social lives, correlation and causation cannot be untangled easily: for example, a study of the elderly concluded those walking about 150 mins/week are more socially active with greater overall well-being than those walking less⁷⁷. Which direction does causality run? Do you walk more because you are socially active, or are you socially active because you walk more? PWs offer a way to untangle correlation and causation, with implications for a key problem for behavioural change, viz., countering the general reduction in physical activity apparent across the world.

A novel, naturalistic, framework for investigating pilgrim walking

Why do humans have the impulse to walk these extraordinary distances in the service of these abstract ends, even today, when we have largely, and deliberately, engineered so much walking out of our everyday lives? Laboratory, treadmill-based, investigations do not address this question; although small-animal and human treadmill studies have been, and will continue to be, mechanistically vital, they cannot, in principle, address why humans walk extraordinary distances together for abstract ends, or suggest how to bring much-needed physical activity back into our everyday lives. Here, we offer a naturalistic framework for investigating pilgrim walking, and, in turn, attempt to derive some policy prescriptions from this population to engineer physical activity into our lives. The overall framework below is an organising set of rubrics to situate pilgrim brain and walking body in the world, moving from the more usual 'top-down' and 'bottom-up' cognitive processing dichotomy^{78,79} in favour of the reciprocal perspectives of '*inside→out*' (the 'world' within the walker), where processes within brain and body initiate, support and entrain movement; and those '*outside→in*' (the walker within the world), where processes in the world beyond brain and body drive activity *within* brain and body. Note, the former '*inside→out*' case, predicts, for example, there should be widespread changes evident in brain and end-organ systems arising from physical activity (for example: increases in circulating factors such as neurotrophins supporting structural change in the brain in those participating in a physical activity programme, and also enhanced performance in hippocampal-dependent memory function (as is the case⁸⁰)). Whereas, the latter, '*outside→in*', case, suggests body and brain are embedded in a physical and socio-cultural context, where sensory transduction occurs through well-delineated sensory channels, but the information processed is various, embracing abstract entities (such as social structures), to more immediate sensory processes (such as the texture and firmness of the ground beneath the feet). These processes, of course, require intrinsic (i.e., brain region→brain region) activity entrained by multiple brain networks supporting action-oriented processes, co-opted both to spatio-physical demands, and to abstract ends – for example, goals as particular physical places, and goals as socially-determined achievements (or both).

From inside→out: Intrapersonal processes support interpersonal transactions with the environment: PW

entrains intrapersonal processing

(Figure 1): these intrapersonal processes are reciprocal, feedforward (*brain*→*body*), feedback (*body*→*brain*), and intrinsic (*brain region*→*brain region*), and support and consolidate changes in brain and body. We further distinguish fast, and slow, actions (mediated via neurotransmission, and neurohumorally, respectively).

The effects of walking are dose- and context-dependent, with greater walking doses of greater effect, depending on the organ

Fig. 1 Personal: PW entrains reciprocal, feedforward (brain→body), feedback (body→brain), and intrinsic (brain region→brain region) intrapersonal processes that support and consolidate changes in brain and body.

system and function (changes in cardiovascular factors, or functional connectivity of the hippocampal formation, for example, will show greater effects for longer distances, eventually asymptoting; whereas moment-to-moment mood may reflect transient variables, but underlying affect should show a dose-dependent, positive, augmentation). These intrapersonal processes are further moderated by social and transcendent processes (discussed below).

A *specific example*: cognitive mapping and wayfinding, supported by hippocampal formation activity, requires sensory input, motor output and intrinsic activity within, and between, differing brain regions. Feedforward processes entraining brain regions initiate and control destination-directed walking through the environment. Fast feed-back loops arising from the vestibular system stabilise movement; cognitive processing of sensory inputs arising from the movement of other walkers allows the prediction of the trajectory of other walkers, enabling collision avoidance, or following, as appropriate^{81, 82}. Transportable factors result from activity: for example, sustained, contractile, muscle activity produces myokines (muscle-secreted molecules⁸³, such as skeletal myofiber vascular endothelial growth factor – smVEGF⁸⁴), which diffuse through the vasculature, changing and enhancing the fabric and functions of myriad brain and body regions. We predict positive changes in pro- and anti-inflammatory factors in blood, as well as sustained expression of certain myokines/factors secreted in blood. Several studies support these predictions. In an endurance-walking case study, Ardigo *et al.*⁸⁵ investigated a single 62-year-old male walking 1300km/68 days over the *Via Alpina*. He adapted quickly and easily to breathing at high altitudes; his body mass index declined by c. 10%; measured body fat fell c. 25%; there was a c. 75% decrease in the triglycerides thought to underlie some

forms of cardiovascular disease and a converse increase in cardioprotective high-density lipoproteins (see also⁸⁶), underscoring our ready adaptation to endurance walking. Bemelmans *et al.*^{87,88} investigated twenty-nine healthy males and females (40-70ya) undertaking at least 280kms of the Santiago di Compostela, concluding there are immediate and positive impacts on the main cardiovascular risk factors because of the strenuous nature of PW (and also perhaps because of some dietary changes and caloric burn); furthermore, higher walking speeds have a more positive impact on cardiovascular health⁸⁹. Finally, those living 'ancestral' hunter-gatherer lives today, regularly walk ~10-15 kms/day and have remarkable cardiac health^{90,91}, which disimproves when they adopt a sedentary lifestyle^{92,93}.

From outside→in: Intrapersonal processes reciprocally support and entrain interpersonal and social interactions:

During PW, intrapersonal processes reciprocally support interpersonal social connectedness, social relationships, and social synchronisation (with those physically, or psychologically, present, or both); these are built on underpinning, consolidating and supporting changes in brain and body (Figure 2), because most 'inner processes serve interpersonal functions'⁹⁴, such as inferring mental states, intentions, and agency of others. Affiliation to a group requires minimal experience

Figure 2 - SOCIAL: During PW, intrapersonal processes reciprocally support interpersonal social connectedness, social relationships, and social synchronisation (with those physically, or psychologically, or both, present); these are built on underpinning, consolidating, and supporting changes in brain and body.

with that group⁹⁵: affiliation happens quickly, and subsequent experience supports the continued expression of group affiliation, even to with arbitrarily-assigned group⁹⁶ (such as a tour group).

A specific example: cognitive mapping and wayfinding are co-opted to serve interpersonal functions: walking groups must find their way to a goal, and co-ordinate individual decision-making processes of group members to do so. Goal-finding by a group requires that the group leverages individual processes to select a/the goal (the eventual destination) of the group. Joint information sharing, joint decision-making and consensus-finding entrain inner individual processes as the group decides on the destination, and the subgoals to be achieved, during wayfinding to the destination. Ensuring the coherent and directed movement of the group requires individuals attend to each other's movements, and synchronise their walking together so that it is directionally- and goal-oriented. As the group grows larger, coordination is more easily achieved by singing, chanting, recitations, or music-making, among other means.

From outside→in and inside→out: Transcendent processes are iterative - driven in part by pre-existing personal traits, but subject to negative and positive feedback from the journey undertaken: PW is undertaken for secular and/or religious reasons, particularly of feeling and meaning-making. Underlying self-reported motivations are psychosocial processes, such as 'meaning-making' – activities that go beyond personal happiness, focusing on larger themes in a person's life. Humans have always sought 'transcendent' feelings – for example, by participating in initiation rites, or the consumption of psychedelic substances. Secular PW is compatible with transcendent feelings: surveys of PWs (Camino walkers:^{68, 69}) disclose multiple reasons for undertaking the walks, and formal religious purposes are a minority (e.g., a penitential pilgrimage). Pilgrim walking can thus be conceived as a form of '*experiential consumption good*', where the goal is 'transcendence', attained by effortfully participating in something from which meaning can be extracted, and where feelings of self and other (people, or nature, or the universe) are blurred. It is entirely plausible that combining some degree of 'in-walk' caloric insufficiency, hypohydration, thermal strain, repetitive, extended, rhythmic, outdoor locomotor activity, prolonged in-group social contact, and the psychological tunnelling arising from the extended walk, in combination give rise to an occasional sense of psychological dissociation, boundaries of self and other dissolving, or even a psychological 'high'. These combined effects might, of course, be misattributed to 'supernatural' origins, despite their rather more prosaic biopsychosocial origins. (Note, this definition of transcendence is empirically testable, in contrast to less-empirically-tractable definitions, especially Maslow's⁹⁷, where transcendence is defined as '...the very highest and most inclusive or holistic levels of human consciousness, behaving and relating' p. 269)

A specific example: Goal-directed behaviour need not be just to a physical destination: it can be an imagined destination (the imagining of which depends on the activity of the hippocampal formation), or even a sought-after psychological state (such as a perception of 'one-ness' with the universe). Religious and secular walkers may find meaning and achievement in finishing the PW, but might attribute the origin of such meaning and achievement to differing sources. MacFarlane⁹⁸ (p. 236), for example, surmises that individual meaning-making is an important factor in PW, not religious motivations. By contrast, some scholars of religion⁹⁹ suggest there is a feeling of religious ecstasy on completing the PW for the religious - a point of 'euphoric climax', (p. 207). Participatory immanence is the name we give here to the feelings experienced of a 'supernatural' manifestation arising from the PW; we extend the concept to the majority non-religious walkers, because feelings of existential communion and universal connectedness may arise from the PW. Certainly, a feelings of 'effervescence' often arise when an individual is a part of larger group serving a collective purpose^{100, 101, 102}; effervescent experience includes increases in feelings of wellbeing, lower levels of self-reported loneliness, and higher levels of positive feeling and meaning. A feeling of 'euphoric climax' is certainly possible, though, it may be complicated by feelings of relief and perhaps even of feelings of loss of immediate purpose, because the journey is now at an end. Degree of self-reported religiosity may, paradoxically, be irrelevant: in study of atheists walking the Camino, Farias et al.¹⁰³ found that religiously-committed and atheist pilgrim walker alike were equally committed to exploring transcendent feelings and

connectedness to nature, suggesting experience, meaning-making and self-transcendence arise naturally from such extended and arduous walks.

'Flow' is the subjective experience of concentration and deep enjoyment accompanying or arising from skilled performance¹⁰⁴, as might arise in extended distance walking¹; awe is conceived of as perceiving vastness and attempting to process the experience of the diminution of the significance of the self¹⁰⁵. Such feelings may combine to give rise to some of the affective changes arising

Figure 3 - TRANSCENDENCE: PW is undertaken for secular and/or religious reasons, particularly of feeling, meaning-making, and participative immanence.

during extended walking. Sturm et al.¹⁰⁶ find an intervention promoting awe during solo walking of 15 min outdoor walks (1 weekly for 8 weeks), compared to control solo walking, enhances reported feelings of joy and of prosocial positive emotions, in addition to increased smile intensity. Spillover effects on positive prosocial emotions and decreases in daily distress over time were also apparent. The temporal duration of these effects is uncertain, but regular practice of 'awe walking' might prove enduringly beneficial, especially as Sturm et al.¹⁰⁶ used a minimal walking dose.

Integration of personal, social and transcendental processes into human functioning

Humans walk can, and do, walk extraordinary distances in a voluntarily-undertaken, psychologically-demanding, and physically-arduous process for abstract ends, in a universal, significant, and enduring human tradition shaping the person, their social, and transcendental world. We posit the integration of PST processes happens within a reciprocal context: from the '*inside→out*', where the walker avails of the extended walk to create new self-narratives and schemas, supported and consolidated by activity-induced neurobiological modulation of various molecular and organ systems, stabilising and consolidating changes in structure and function of brain, body and beyond; and from the '*outside→in*', because human walking is a socially-embedded and socially-moderated biological adaptation, entraining and supporting extended movement in particular geographical locales and social contexts. In both cases, lessons from pilgrim walking can shape active living and well-being throughout the life-course.

Malign consequences of physical inactivity

Selection effects have ensured regular, physical activity is profoundly health-promoting in humans¹⁰⁷: the average 80yo Tsimane in the Amazonian jungle, for example, living a non-mechanised 'ancestral' lifestyle, walks everywhere, and has a cardiac health equivalent of an average westerner 25 years younger⁹⁰. Humans must balance two opposing metabolic drives: food-sourcing (for energy), and energy conservation¹⁰⁸. Historically, these drives have rarely been in balance, with food sources rare, and energy conservation at a premium. 19th C day labourers in London, for example, typically walked ~6-8 miles/day (c. 9-13km, to and from work^{109, 110}). In the 21st C, cheap calories are plentiful, but we have engineered movement out of our daily working and leisure lives¹¹¹, with adults in high-income countries walking typically c. ≤4-5k steps/day (3-4km)¹¹². <5k/steps a day is defined physiologically as sedentariness, bringing a correlated surge of non-communicable diseases, ranging from type two diabetes to major depressive disorder^{113, 114}. The World Health Organisation and other agencies have repeatedly concluded rising physical inactivity levels¹¹⁵, diseases of aging, and of metabolism, are a major problem in many societies, exacerbated as the World's population ages^{116, 117}. Many diseases of aging are preventable through prophylactic measures^{118, 119}, especially regular exercise: active lifestyles are universally recommended for their health-promoting properties, and for preventing non-communicable diseases (even major depressive disorder¹²⁰, and diseases of ageing^{121, 122}). Physical activity can abrogate pathologies of cognition accompanying ageing (e.g.^{123, 124}); consequently, the neuroscientific consensus concurs with active lifestyle advice: exercise benefits *all neurocognitive domains* (from memory, executive function and beyond)²².

Can lessons from pilgrim walking shape active living and well-being throughout the life-course?

The lesson of biomedical science is physical activity is profoundly health-promoting (and walking is a particularly accessible form of exercise throughout the lifecourse); however, the challenge for social sciences is to discover how we can increase activity, to avail of these health benefits. We know relatively little about how psychosocial mechanisms can facilitate increase physical activity¹²⁵; the challenge is identifying and entraining causal feedback and feedforward psychosocial processes, and employing them to increase activity levels. 'Social-prescribing', for example, has been attempted to increase levels of physical activity, but has not yielded large-scale activity increases^{126, 127}, possibly because social-prescribing efforts are often not theoretically- or empirically-grounded, or sufficiently embedded in other larger cultural or policy changes to increase physical activity in society generally. Here, we draw some tentative, and perhaps generally-applicable, lessons from pilgrim walking to foster increases in physical activity, using the '*outside→in*' and '*inside→out*' perspectives:

From '*outside→in*': Pilgrim walking is a socially-embedded and socially-exercised expression of psychologically-demanding, physiologically-arduous, and temporally-extended, walking, serving abstract, challenging goals, and yet we readily adapt to it. The social context of the walker seems especially important, providing the necessary social motivation, challenge and support, further boosted by group membership and affiliation. Individual motivation is perhaps less important, compared to the importance of being individually

incorporated into extended, social motivational structures supporting regular bouts of individual locomotion within a group populated by others with whom we are affiliated. Increasing levels of walking generally might therefore attempt to use social walking groups more effectively, perhaps organised through social media, rather than traditional, advertising-based, admonitory, campaigns focused on individuals. Social prescribing to increase physical activity might therefore require active group leadership, enrolment, involvement and engagement through social media to be successful. Creating local walking groups with smartphone app route mapping and pedometry capture¹²⁸ offers one low-cost method to encourage walking; creating league tables harnessing gentle inter-group competition focused on step counts by teams, harvested by such an app, might be another. Pilgrim walking succeeds as an endeavour through regular daily repetition; progress requires the pilgrim to daily complete a target of kilometres and way-stations, along with walking companions. Thus, building adventitious walking as an engineered by-product of the design built of the environment will assist in increasing physical activity levels. Two particular design components are of particular interest: firstly, 'hard' changes in building design that ensure people engage in active movement via stairs, corridors, and secondly, 'soft' changes facilitating active workspaces (which can reduce territoriality and increase creative idea production¹²⁹). Walking desks, as a component of an active workspace, can encourage low-level, consistent walking through the day¹³⁰, mimic in part the constant demands of pilgrim walking, and offer physiometabolic benefits (including substantial weight loss)¹³¹, with benign to positive effects on cognitive function^{132, 133, 134}.

From 'inside→out': aside from its physiometabolic benefits, walking is intrinsically rewarding, especially so in nature, providing underestimated boosts to affect, even in those who 'dread' or dislike walking¹³⁵, thereby contributing to psychological wellbeing (perhaps in an enduring, dose-dependent way). Pilgrim walking routes often employ rural trails, avoiding the built environment; interestingly, study participants typically markedly underestimate how much walking in nature will boost their experience of in-walk and post-walk positive affect¹³⁶. A growing body of evidence points to the importance of nature exposure for mental health¹³⁷; although we spend the vast majority of our time indoors ($\geq 85\%$)¹³⁸, we evolved in an outdoor environment, spending most of our evolutionary history in a non-urban setting, where selection effects likely rewarded perception of important environmental signals, such as sources of food, shelter and refuge^{139, 140}. Green space exposure through active usage of urban parks can have a marked and positive effect on the diurnal variation in the secretion of the stress hormone, cortisol¹⁴¹, further supporting positive feedback loops between walking, nature exposure and mental health. A risk factor for major depressive disorder is maladaptive patterns of self-referential thoughts (rumination); short periods ((90 mins) of walking in nature can substantially reduce rumination, compared to urban-only walks¹⁴². Combining nature/green exposure and experiences using apps with crowd-sourced feedback might therefore be of particular use to boost physical activity. Pilgrim walking requires regular, structured, diaried performance for successfully completing a lengthy walking route; integrating social media apps with a regular, diaried walking group appointment is now trivial, but may provide the simple, additional mnemonic nudge required to increase levels of walking. Walking apps could incorporate prompts for 'awe-walking'; the sustained and regular

practice of awe-walking might provide necessary support for the 'psychological immune system'¹⁴³, again providing an important boost to general mental and physical health.

Conclusions

Pilgrim walking is an underexplored, but universal, human behaviour, with roots deep in our evolutionary past, likely arising from selection effects on both our physiometabolic health and on numerous neurocognitive, social, and affective processes, binding us to our groups and their goals. This urge to engage in, and profit from, extended bouts of walking is best understood in a social context, and as a social behaviour bringing collateral, generally positive, personal changes, which occasionally include inducing transcendental states (the latter best understood as desired outworkings of biopsychosocial processes of the body and brain under rhythmic, physiometabolic, strain in a specific social context). Pilgrim walking offers lessons for effective support for physical activity programmes, through entraining social-group membership coupled to individual affiliative processes. Supporting physical activity programmes, however, require changes in the built environment explicitly supporting socially-embedded walking programmes, through the provision of safe and extensive pedestrian infrastructure (with adaptations for persons with mobility impairments or other disabilities), and ample urban green space provision or such campaigns will fail to raise physical activity levels more generally, despite public health goals. Public health goals and urban planning must also meaningfully align for such campaigns to be effective: biomedical and social science advice alike must therefore be incorporated into public policy making addressing physical activity goals¹.

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