Joint Action and Social Bonding Between Professional Chinese Rugby Players

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Abstract

The key assertion of this dissertation is that mechanisms responsible for coordinating physical movement in social interaction must be more fully incorporated into a cognitive and evolutionary anthropology of social cohesion. To explore and substantiate this assertion, I conduct research with professional Chinese athletes who participate in the competitive interactional team sport of rugby union. I utilise ethnographic and pseudo-experimental methods in order to examine the specific relationship between joint action and social bonding. Results provide evidence for a relationship between athletes' perceptions of success in joint action and social bonding. Interestingly, this relationship appears to be mediated by "team click" —a novel construct, theoretically grounded and ethnographically substantiated, which pertains to the subjective feeling associated with optimal interpersonal coordination. Considered in light of existing debates on the process mechanisms of social cohesion, these results suggest that processes of psychophysiological alignment achieved through interpersonal movement regulation could be central to the formation of durable social bonds and the transmission of cultural practices between individuals and within groups.

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Introduction

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Sun Hongwei arrived escorted by his high school athletics coach to the Beijing Agricultural Temple Institute of Sport (hereafter the Institute) soon after I began my fieldwork in August 2015. An 18 year old with a very slight build and timid demeanour—his gaze always diverted to the ground during the first few months of his tenure at the Institute—Hongwei had never seen a rugby ball before that day he first arrived. Hongwei was from Hebei province, immediately surrounding the special prefecture of Beijing, China's capital. As was relatively common practice in professional sport programs such as this one at the Institute, Hongwei's coach had organised a trial for Hongwei with the Beijing Provincial Men's and Women's Rugby Program (hereafter the Rugby Program) by calling upon social connections to the leadership of the Institute.

Athletes come to the Rugby Program from all over the country. Representing Beijing at a provincial level in a sport like rugby can translate into the opportunity to gain entrance—via a designated "specialist athlete" (*tiyu techan*) pathway—to one of China's top universities (Beijing Sports University, in this case) and enhanced career employment opportunities thereafter. Rugby is not a popular sport in China, and is referred to as a neglected or "cold-gate" branch of the Chinese sport system (*lengmen xiangmu* , a term that refers to a profession, trade or branch of learning that receives little attention). Despite its minnow status in China in terms of its popularity, rugby's recent inclusion in the Olympics (in the form of the modified 7-a-side version of "rugby sevens") means that it now occupies a prominent place in the Chinese sport system, which has been defined since its inception by a strong Olympic logic (Brownell, 2008). If a sport is a current member of the summer or winter Olympic Games, then the sport is included in the roster of sports played at the quadrennial China National Games (*quanhunhui*). As such, rugby programs such as the one at the Institute now exist in twleve of China's 34 provincial level regions, either embedded within or somehow associated with tertiary education institutions. Thus, although rugby and China are two words that have not historically not commonly featured within the same utterance, rugby in China now affords athletes a rare and under-capitalised opportunity to pursue attractive life-course opportunities of education and employment, in an otherwise intensely competitive sport system.

Almost without exception, the athletes who arrive at the Institute to join the rugby team have not spent their childhoods playing rugby in their school yards or watching professional rugby on television. In fact, many who come to rugby transition from other more popular sports such as athletics, basketball, or association football, and often—like Hongwei—have never seen a rugby ball before they arrive. Most "start from scratch," so to speak, in terms of their grasp of the technical and social requirements of the highly interactive and technically complex team sport. In addition to complex patterns of movement coordination, rugby also involves "full contact" body-on-body collisions and intense bouts of high physiological exertion, requiring speed, strength, agility, and endurance to perform all of rugby's technical requirements successfully. Learning the game of rugby from a baseline of essentially zero, while also navigating the demanding social and political dynamics within the team and the Institute, was clearly going to be a daunting task for Hongwei.

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1.1 Thesis overview

Whirling Sufi dervishes, late-night electronic music raves, Maasi ceremonial dances, competitive team sports, or the fitness cults of Cross-fit and Soul Cycle—endless examples can be plucked from across cultures and throughout time to exemplify the human compulsion to come together and move together. How is it possible to explain the prevalence of physiologically exertive and socially coordinated movement in the human record?

Physical movement is a metabolically expensive endeavour for all biological organisms, and appears justifiable, in an evolutionary sense at least, only if the benefits somehow outweigh the costs. It is easy to imagine how physiologically exertive and coordinated group activities (hereafter simply "group exercise") would have served important survival functions in our ancestral past, such as hunting, travel, communication, and defence (Sands & Sands, 2010). The task of explaining the persistent recurrence of group exercise in more recent domains of human history (at least since the late Pleistocene era (approx. 500ka), and particularly since the Holocene transition (approx. 11ka) from hunter-gatherer to agricultural, and later industrial and post-industrial societies), however, appears much more complicated. Cross-cutting shared cultural practices as varied as religion, organised warfare, music, dance, play, and sport, the fitness-relevant benefits of group exercise are not so immediate or obvious. Instead, causal explanations for the prevalence of group exercise are thoroughly intertwined with the processes of a species-unique evolutionary trajectory, defined by increasingly complex cognitive and cultural capacities, including technical manipulation of extra-somatic materials and ecologies, advanced theory of mind, and information-rich, malleable, and scaleable communication systems (Fuentes, 2016). A theory capable of satisfactorily explaining group exercise within these distinctive evolutionary parameters is yet to be fully formulated (Emma Cohen, 2017).

In this dissertation, I evaluate existing theoretical explanations for the ubiquity of group exercise in human sociality through specific reference to an empirical case study of professional Chinese rugby players. Conducted periodically between August 2015 and September 2017, research for this dissertation includes extended ethnographic and field-experimental analyses of a psychological phenomenon I term “team click”—a subjective perception of the tacit *quality* of coordination in joint action among athletes. Similar in many respects to psychological states associated with “flow” and peak performance (Csikszentmihalyi, 1992), team click is anecdotally common in a wide range of joint action contexts, and is often associated in these contexts with psychological processes of positive affect and wellbeing, as well as personal agency, social affiliation, and group membership (S. a. Jackson, 1995; Marsh, Richardson, & Schmidt, 2009; Wheatley, Kang, Parkinson, & Looser, 2012). The contextual antecedents and psychological consequences of flow and related states have by now been well established (Fong, Zaleski, & Leach, 2015), but very few direct attempts have been made to empirically verify the social cognitive mechanisms underpinning such experiences, or their broader evolutionary significance (but, for a (neuro)cognitive account, see Dietrich & McDaniel, 2004; A. Dietrich & Audiffren, 2011; Cheron, 2016)(and for an evolutionary framing, see see Slingerland, 2014; Haidt, 2007). Following a detailed review of cognitive and evolutionary approaches to human behaviour group exercise specifically, I suggest that novel rationales for the evolutionary significance of team click can be found within the research domain of the social cognition of joint action. From an evolutionary perspective, interpersonal coordination is an adaptive behaviour from which humans derive numerous benefits (Michael Tomasello, 2014a). It is therefore plausible that we have evolved physiological, cognitive, and social mechanisms that reward effective joint action with others.

The core prediction of this dissertation is that the phenomenon of team click mediates a relationship between joint action and social cohesion. I present ethnographic and field-experimental evidence that tests and confirms this core prediction, and I evaluate these results in terms of their implications for understanding the proximate cognitive mechanisms, ecological system dynamics, and ultimate evolutionary processes relevant to the anthropology of group exercise. In particular, I identify the social cognition of joint action as a research domain containing rich theoretical and methodological possibilities for critically examining the sturdiness of assumptions associated with existing cognitive and evolutionary accounts of human behaviour.

In the sections that follow in this introduction—in addition to continuing the story of Chinese rugby’s newest recruit, Hongwei—I review the adequacy of existing cognitive and evolutionary theories of human behaviour for explaining the ubiquity of group exercise in human sociality. This review unfolds in three stages. First, I assess the theoretical foundations, protocols, and disputes associated with evolutionary approaches to behaviour grouped within the paradigm known as the “modern synthesis." Second, I outline attempts made from within this paradigm to account for the distinctiveness of the human evolutionary trajectory. Third, I evaluate existing evidence concerning the immediate social, cognitive, psychological, and neurobiological mechanisms hypothesised to underpin group exercise, as well as attempts to provide ultimate evolutionary explanations for the human cultural activities in which group exercise commonly feature.

Following this review, I draw attention to the phenomenon of team click and the social cognition of joint action as a research domain in which some key knowledge gaps in an evolutionary explanation of group exercise can be addressed. Subsequently, I formulate the specific predictions of my thesis and introduce the empirical research designed to test them. Finally, I conclude this introductory chatper by outlining the empirical contributions of this dissertation and suggesting theoretical and methodological considerations for the cognitive and evolutionary anthropology of group exercise (which I develop fully later in the General Discussion, Chapter 8).

1.2 Sun Hongwei, rugby's newest recruit

Hongwei was the first of the program's new recruits that I followed closely, and so perhaps I was more attentive to his journey than others. Compared even to other newly arrived junior athletes, he was noticeably timid and shy, particularly in his interactions with the coaches (myself included) and senior players. At the same time, however, Hongwei clearly signalled diligence and commitment in the way that he participated in team activities. He arrived early to each training session carrying more than his fair share of the training equipment required for the session (balls, plastic cone markers, tackling shields, and so on—a task delegated to the most junior members of the team). Each time I passed Hongwei in the corridors of the Institute he would greet me with a polite bow and greeting, "Hello Coach" (*jiaolian hao*). In these instances Hongwei would coorindate his greeting with a moment's eye contact, only to return his eyes directly back to the floor and continue walking.

Owing to his initial lack of grasp of the basic techniques of rugby, Hongwei was unable to properly participate in normal training with the rest of the team. Instead, during the first month or so Hongwei stood on the sidelines of the training session and practiced the basics with other athletes who were unable to fully participate in training due to injury: learning how to pass and catch the rugby ball, both stationary and in-motion. In my eyes at least—those of an observer accustomed to instinctual grasp of these distinctive movements from a young age—Hongwei's attempts to accustom himself with the skills of rugby were distinctly jarring. The bizarre idiosyncrasies of rugby's ovular ball often foiled him, and I would regularly see Hongwei chasing after a ball he'd just fumbled, as if he was chasing in vein after a scurrying rabbit tactfully evading his pursuit. In my time coaching and playing rugby in China I have watched many start exactly where Hongwei was starting, on the sidelines of training, learning how to pass the ball. But for some reason I found Hongwei's attempts to learn particularly unusual. Hongwei's actions appeared so mechanical that it was almost as if he was deliberately (over)imitating the required actions of passing, catching, and running as a signal of diligence and commitment (at the expense of any personal reckoning or negotiation with these prescribed techniques).

A few weeks in to Hongwei's time at the Institute I asked head coach Zhu Peihou about his newest recruit. He immediately shook his head and scrunched up his face dismissively, adding in a disappointing whisper, "no good" (*buxing*). Chinese rugby coaches were well acquainted with athletes starting from scratch with the technical requirements of rugby—they were used to things looking awkward and ugly at the start. In my experience, coaches appeared more interested in the physical raw materials that would enable athletes to develop into rugby players over time. Often this meant that coaches had a habit of fixating on an athlete's baseline characteristics of height and body frame as an indication of their capacity to develop physical speed, size and strength deemed crucial for elite performance. Also important, but less crucial than these physical attributes, was an athlete's baseline ball-handling skills and "game sense" (often assessed in by coaches by observing new recruits participating in analogous interactive team sport scenarios like basketball or association football). Hongwei was still relatively young and physically undeveloped when he arrived, but at the same time was by no means endowed with a big physical frame, nor was he noticeably fast or agile compared to other athletes. For all these reasons, head coach Peihou couldn't help but let on to me that he was not particularly excited about Hongwei's future prospects in the Program. In fact, I got the sense that his reaction to my question contained an element of annoyance or frustration with the terms under which Hongwei had arrived to the Institute, i.e., via the arrangements of Hongwei's athletics coach. According to his own assessment of Hongwei's ability and future potential, Peihou had perhaps conceded that he had been forced to accept an athletic "dud" into the team.

I interviewed Hongwei approximately 6 weeks after he had first arrived at the Institute. Hongwei's demeanour during the interview was consistent with the demeanour that he presented publicly at training. Although he was timid and shy, he did also show some signs of excitement and captivation with his new sport and social environment. When I asked him about his initial impressions of the on-field demands of rugby, however, Hongwei was quick to confess that he felt very unacquainted:

> Hongwei: I still haven't really started to practice any of the team plays or anything, all I can do so far is pass and run a little bit...(but) its quite fun!
> JT: What do you think is the most difficult component of rugby?
> Hongwei: Umm..well, coordinating with teammates [on the field], particularly coordination in attack. Because I can't figure it out. When I first arrived I didn't even know what a "switch play" or a "blocker play" was.
>
> ：战术没怎么接触，就是像传球啊、跑动什么的会一点了
> ？感觉怎么样?
> ：挺好玩的！
> ？你认为橄榄球最难的一部分是什么?
> ：...打配合，进攻的配合，因为搞不明白，刚来的时候也不知道什么交叉，后插什么的

When discussing the technical demands of rugby, Hongwei was bashful when confessing his lack of grasp of these requirements. As I will explain in more detail in the ethnographic sections of this dissertation (Chapters 3 and 4), when athletes were asked in interview about their impressions of the most difficult aspect of rugby, on-field coordination with teammates was by far the most common answer, particularly among junior athletes (rugby training age < 3 years).

As I directed the interview towards other topics beyond the on-field technical demands of rugby, Hongwei was more positive, framing rugby as an exciting new opportunity, and commenting that his friends and family were in awe of the fact that he is playing such an impressively "strong" physical sport like rugby. When I asked what was new about rugby that he hadn't experienced before elsewhere, Hongwei was very automatic in emphasising the social dimensions of his experience at the Institute:

> "...I think its mainly this thing of having teammates. Before when I was training for an individual sport it was just me training by myself. (In that environment) it was a case of: whoever trained well was successful. But now with this team of brothers, elder teammates will take care of younger teammates. We all train together, and if you can't do something you can always ask your elder teammates...[Rugby] is so much better, because in an individual sport, if you can't master something, you have to go to your coach for help. Other athletes don't want to teach you, because if you surpass other people, then they have to work even harder to keep up... I have had to learn about helping each other, because

> rugby is not like an individual sport, where you look after your own performance and thats it. In a team sport, if you don't do well, there's no need to get too frustrated or upset, because other athletes will help you out, and I will also help others out, that type of collaboration with each other."
>
> ：我觉得主要是师哥师弟的这一块儿，原来练个体项目都是自己练自己的，谁练好了谁厉害，但是现在师哥师弟,有师哥照顾师弟带着，互相练，我不会我可以问师哥：好多了，因为个人项目你不会就必须要找教练，但是别人不愿意教你，因为你把别人超越了，那别人还还得努力。(3)：学到互相帮助，因为向个体项目自己成绩自己来拿就行，而像团体项目，即使自己做不好，也不用太泄气太沮丧，因为别人会帮你做好，我也会帮别人做好，互相协作的那种.

Having migrated from his previous high school sport of pentathlon (track and field / athletics – an individual sport) it was clear that the technical skills of rugby were not the only novelties Hongwei had encountered at the Institute. Hongwei makes explicit reference to the mutual social support of the fraternity of the Program, and his place in it as a junior member. As I listened to Hongwei tentatively but conscientiously recount his experiences associated with rugby and group membership, I could not help but associate these explicit flourishes in reference to team support with his overly mechanical imitation of rugby's foundational techniques of rugby. It was as if somehow both were related as equivalently diligent (albeit somewhat unsophisticated) signals of team commitment.

* * *

A few months passed and Hongwei continued to train: as eager and committed as when he began, and I did notice some gradual improvement in his grasp of rugby's basics to show for it. But he also remained extremely reserved, keeping his head low at all times in team settings, unless addressed by senior players or coaches. Then, one evening when I had returned to my room in the Institute dormitory from a three-week hiatus in Australia over Christmas of 2015, I heard a knock on my open door, and to my surprise Hongwei took an assertive stride into my room, carrying in two arms a draw-string bag containing rugby balls (which were in need of more air before the next day's training session). Hongwei had never ventured into my room before on his own accord, apart from when he was scheduled for the interview that I conducted with him two months earlier. Remarkably, Hongwei looked me straight in the eyes with his head held high and energy beaming from his face and chest. I couldn't help but smile and ask, with genuine intrigue, "How has training been recently?" "Very good" he said, assertively and excitedly. "Much better than before. At least now I know what's going on at training, I can keep up with the plays!" A big smile grew on his face as he continued to hold my gaze. "Oh good!" I said, and I congratulated him for his hard work in training while I had been away, and encouraged him to keep at it. Wow, I remember thinking to myself, the "force" was in him. Somehow Hongwei, rugby, and the team in which he was by now enmeshed had interlocked to instil him with a visceral sense of agency.

A few weeks later, the new head coach of the Program, Chongyi (who took over from Peihou who abruptly resigned while I was away in Australia) told me that he had decided to take Hongwei to pre-season training in Guangzhou, for a month starting in March 2016. Chongyi admitted that while he was perhaps not the most promising of the junior athletes, his attitude was very good:

> "He [Hongwei] likes to train, and he is very diligent. I want to take his positivity with us [to Guangzhou]" 他爱练，而且很用心，带上他的积极性过去

* * *

These ethnographic observations relating to Hongwei's first four months at the Institute highlight key themes of this dissertation. As I will outline in Chapter 2, existing research suggests that successful coordination in joint action requires alignment and maintenance of equivalent expectations between co-actors (Sebanz, Bekkering, & Knoblich, 2006; Vesper et al., 2017; Pesquita, Whitwell, & Enns, 2017). Importantly, evidence also suggests that violation of expectations in joint action has strong affective consequences (Chetverikov & Kristjánsson, 2016). Hongwei's story is emblematic of various other athletes who I followed closely between August 2015 and September 2017. These collections of ethnographic observations suggested to me that the covariation (over time) of athletes' 1) familiarity with the technical requirements of rugby, 2) personal demeanor in social settings, and 3) attitudes towards group membership, was worthy of further investigation. As I explain in Chapters 3 and 4, my ethnographic observations reveal broader variation in associations between perceptions of joint action performance, team click, and feelings of social bonding. These observations, coupled with predictions from existing literature within the social cognition of joint action, set the foundations for subsequent field-experimental studies in which I test specific relationships with a broader subset of Chinese professional rugby players beyond the Program at the Institute.

I do not have the data to confirm or reject this hunch, but I suspect that in Hongwei's case, the quantities that covaried over this period of 4 months time would not have actually included his explicit attitudes towards group membership (expressed to me in an interview setting). At the point at which I interviewed him, only 6 weeks into his internship at the Institute, Hongwei was relatively fluent in articulating his role in the team as junior member, and the social support he derived from team membership. Ideas about familial modes of group membership such as the ones Hongwei expressed in his interview above are culturally salient in China, and such notions are emphasised on every level of social organisation from the immediate nuclear family unit, community neighbourhoods, corporate organisations, or even the Nation State (literally "State Family" *guojia*). Be it six weeks or six months into his stay at the Institute, I suspect Hongwei would have produced a relatively similar account of his attitudes towards group membership in an interview setting. It is also worth considering that Hongwei's fluency in declaring positive, pro-social ideas surrounding group membership may also function as a signal of prosocial commitment, made from a position of underlying insecurity in the team as one of the newest—and therefore most socially precarious—recruits. Indeed, as I go on to report in the ethnographic sections of this dissertation, junior athletes of the Beijing Men's Rugby program were generally more willing to make positive pro-team declarations, emphasising ethics of mutualism and feelings of social support. Senior athletes by contrast appeared under less pressure to reproduce such ideas in interview context. Instead, senior athletes were more likely to either remain agnostic or show reluctance to endorse ideas about prosocial group membership. Alternatively, more senior athletes would complain to me about the lack of cohesive group membership in the program, due mainly to the lack of conscientiousness of junior athletes, who were, according to more senior athletes, more concerned with computer games, girlfriends, and/or university degrees than they were with the details of joint action in rugby.

Crucially in Hongwei's case, what did appear to vary markedly during this four month snapshot, however, were quantities much less accessible in an interview setting—I suggest that these quantities may include his sense of personal agency and energy derived from increased familiarity with the technical and social requirements of rugby. Conceding that many complex factors are at play all at once in the ethnographic setting, I nonetheless pursue the possibility that the vitality that I noticed in Hongwei after returning to the field from Australia that evening, was in some part associated with cognitive processes of aligning expectations and coordinating movement in the specific joint action context of rugby. As I explain below and in Chapter 2, various strands of existing research support this possibility.

1.3 What are the theoretical options for explaining group exercise?

How is it possible to scientifically account for the unmistakably "visceral" quality of Hongwei's transformation from timid newcomer to budding Beijing rugger bugger? How does a knowledge of generalisable cognitive and social mechanisms underpinning this ethnographic observation improve our ability to comprehend the evolutionary significance of group exercise in the human record?

In this section, I review existing cognitive and evolutionary theories of human behaviour and assess their usefulness in explaining dimensions of group exercise. In addition to the empirical contributions (ethnographic and experimental studies) of this dissertation, the novel theoretical framing I propose for interpreting these empirical studies, derived from within the social cognition of joint action and centring on the phenomenon of "team click," also serves as a substantial contribution of this thesis. It is therefore necessary in the following review that, much like Hongwei, I start from scratch, so to speak, with the theoretical underpinnings, founding protocols, and commonly encountered contentions associated with evolutionary approaches to human behaviour. As such, I begin with the foundations of the "modern synthesis" of evolutionary theory, before evaluating the ways in which approaches emanating from this paradigm have been applied to the problem of human behaviour. With these options in mind, I proceed to a review of current evolutionary explanations for group exercise. Subsequently, I preview the characteristics of team click and provide justifications for a novel cognitive and evolutionary framework for the social cognition of joint action, which I outline in detail in Chapter 2 and test thereafter in three empirical studies (Chapters 3 - 6).

1.3.1 The Modern Synthesis

Generally speaking, rigorous and scientifically testable accounts of human behaviour have emerged in the last 70 years, facilitated by 1) the gradual refinement of evolutionary theory over the last 200 years now known as the "modern synthesis," as well as 2) the "cognitive revolution" of the 1950s and 60s, in which mechanisms associated with information theory, cybernetics, and computation provided useful conceptual metaphors for understanding population-level transmission and fixation of biological and cultural variants. Below I provide a brief overview of the main assumptions, protocols, and critiques of the modern synthesis, identifying knowledge gaps and research opportunities along the way.

The modern synthesis (also known as "neo-Darwinism", hereafter simply MS) refers generally to the gradual maturation of evolutionary theory in the last 200 years, and specifically to the unification of the theory of evolution by natural selection (attributed to Darwin and Wallace in the second half of the 19th century) with a theory of genetic inheritance (replacing a previously popular theory of blended inheritance). The MS was first proposed by Huxley in 1942, following successful mathematical formalisations performed by population geneticists between 1930 and 1947 (e.g., Fisher (1930) and Haldane (1932)). Subsequent advances in molecular biology and genetics, including the verification of the structure of the DNA molecule by Wallace and Crick in 1954, paved the way for a definition of biological evolution as changes in the frequency of heritable DNA sequences in a population due to selection pressures exerted at the level of the phenotype (Dawkins, 1976; Grafen, 1984). Shown to be mathematically plausible, the mechanism of genetic inheritance served to explain observable intra-species phenotypic variation (for which the preceding theory of blended inheritance failed to account), and confirmed Darwin's original insight that organismic change occurs via gradual population-level accumulation of adaptive traits over evolutionary time. The MS and its associated methodological innovations and empirical findings have collectively transformed scientific knowledge of the historical origins and function of biological life, including human life. The modern synthesis has been widely touted as the second most successful theory in the history of science after modern quantum physics in its ability to explain and predict the world in which we live (Dunbar, 1996).

The power of the MS to account for observable biological phenomena hinges on two interrelated assumptions: (1) evolutionary explanations of a biological trait are solely determined by the process of natural selection, and (2) the consequences of the process of natural selection accumulate in the germ-line in the form of statistical frequencies of programs (alleles) for specific phenotypic traits. As Mayr first suggested in 1961, these two interrelated assumptions create conceptual space for two distinct but complimentary explanations of observable biological phenomena—one evolutionary or "ultimate" level, and one developmental or "proximate" level (Mayr, 1961). Explained in detail below, the "proximate-ultimate" distinction is a core epistemological and pillar of the MS.

Assuming that natural selection is the primary agent of evolutionary change, biologists interested in an evolutionary explanation can largely set to one side immediate processes that contribute to the development or causation of a biological trait, and instead focus on the adaptive value of a trait and its phylogenetic history. (Mayr, 1961; Tinbergen, 1963). Proximate causal mechanisms and developmental processes are not passed on in the germ-line and are thus relatively inconsequential to macro-scale processes of evolutionary change ((Dawkins, 1982; Alan Grafen, 1991; Svensson, 2017) but see (**Laland2012**; Kevin N. Laland et al., 2015). Meanwhile, biologists interested in an explanaining the developmental processes and immediate causal mechanisms associated with a trait can proceed under the assumption that an observable phenotypic trait is the product of interaction between the organism's internal evolved biological programs (genes) and external environmental triggers or cultural capacities emanating from gene-environment interactions within a specific phenotypic niche (SOURCE). Importantly, proximate and ultimate levels of causation must be considered together, as distinct but complimentary components of an overall explanation of the biological phenomena(Mayr, 1961; Tinbergen, 1963; Scott-Phillips, Dickins, & West, 2011).

In the case of the commonly cited example of a human infant crying (taken from (**Zeifman2001**; Scott-Phillips et al., 2011; Nettle, 2009)), a proximate explanation of this behaviour would require an account of both the external (e.g., physical separation from the caregiver, lack of food, cold) and internal (e.g., activity of the limbic system to initiate crying or the role of endogenous opioids in the cessation of crying) factors responsible for the crying behaviour (Scott-Phillips et al., 2011, p. 38). An ultimate causal explanation for human infants crying includes both a description of the adaptive value of crying (e.g., crying elicits support and defence from mothers and other care-givers; infants that do not cry when in need of assistance are less likely to survive), as well as an account of its phylogenetic history (Mayr, 1961; Tinbergen, 1963). Any explanation of biological phenomena requires an account of both proximate and ultimate levels of causation—simply knowing *how* it is that an infant cries (proximate), or alternatively only knowing *why* it is present in the phenotypic repertoire (ultimate) is not enough to satisfactorily account for the observed phenomena (Scott-Phillips et al., 2011, p. 38). In effect, the MS protocol of distinguishing between proximate-ultimate levels of explanation constructs two simple and testable causal models on complimentary levels of biological time—one being the phenotypic lifespan of the organism (proximate), the other being the phylogenetic (evolutionary) trajectory of the species. In so doing, the proximate-ultimate distinction facilitates an efficient division of labour in the dauntingly complicated task of wrangling into a theoretically consistent and empirically substantiated scientific domain, the complex, continuous, and historical processes of biological life (Mayr, 1961). In this regard, the MS has facilitated communication and integration between what were previously disparate strands of biology around a single explanatory project (Svensson, 2017).

Ever since the first declarations of the viability of a theoretical synthesis between Darwinian natural selection and Mendelian genetic inheritance, momentum in favour of the simplifying assumptions and protocols of the MS outlined above has been coupled with theoretical undercurrents pulling in an opposing direction, in the form of periodical critiques, revisions, and proposed extensions to the MS that call these assumptions and protocols into question (**Waddington1950**; **Gould1980**; **Ingold1990**; **Ingold1995**; **Odling-Schmee2003**; **Piggliuci2007**; see, for example Levins & Lewontin, 1985). Generally speaking, critiques boil down to the claim that the simplifying assumptions and protocols of the MS (such as the proximate-ultimate distinction) do not satisfactorily account for the causal complexity of evolutionary processes (K. N. Laland, Sterelny, Odling-Smee, Hoppitt, & Uller, 2011). In the most recent calls for an "extended evolutionary synthesis," (EES, see Pigliucci, 2007), for example, researchers claim that the dichotomy between proximate and ultimate causal models impedes adequate theorisation and measurement of the ways in which proximate-level processes are linked with ultimate-level evolutionary processes via positive and negative feedback loops of reciprocal causation (Pigliucci, 2007; K. N. Laland et al., 2011; Kevin N. Laland, Odling-Smee, Hoppitt, & Uller, 2013; Mesoudi et al., 2013; Kevin N. Laland et al., 2015). Evidence within developmental biology suggests that processes of ontogeny typically understood as "proximate" (and therefore inconsequential to evolutionary change) can shape and co-direct evolutionary trajectories through reciprocal processes that "reverberate" through the organism (Kevin N. Laland et al., 2013). Proponents of the EES outline key domains such as developmental bias, extra-genetic forms of inheritance (i.e., epigenetic, parental, or cultural systems), niche construction, and phenotypic plasticity, which can be responsible for initiating evolutionary episodes and shaping evolutionary outcomes within specific evolutionary niches (Kevin N. Laland et al., 2015). The EES thus challenges the exclusive position of natural selection as the sole director of evolutionary change. Instead, it has been suggested that the emphasis on natural selection in the evolutionary landscape should be relaxed to make room for the modelling other demographic, social, and spatial factors that are hypothesised be responsible for the influence of population-level distributions of genetic and phenotypic variants (Mesoudi et al., 2013). The key methodological and empirical challenges to this suggestion is that these factors often often spontaneously (self-organising) emerge as system dynamics, making them harder to manipulate and measure in traditional "snapshot" experimental paradigms (Svensson, 2017).

The key claim of the EES is captured by developmental biologist and leading proponent of the EES, Keven Laland's inversion of E O Wilson's original proclamation made in 1978, against the prevailing behaviourist paradigm common within the human sciences at the time, that human culture is held on a genetic "leash" (Wilson, 1978). In 2017 Laland claimed that genes should be more accurately depicted as dog-walkers struggling to retain control of a number of unruly dogs (niche construction, developmental plasticity, developmental biases, non-genetic inheritance, etc) pulling in different directions at different intensities (West-Eberhard, 2003; K. Laland, 2017). Evolution, in this image, is depicted by the outcome of the struggle between dog-walker and dogs. As Laland (723 Kevin N. Laland et al., 2013) and colleagues suggest, "much of adaptive evolutionary change may have its origin in plastic responses to novel environments, later followed by genetic changes that stabilize and fine-tune those phenotypes, rather than the other way around." Only by modelling and quantifying the dynamic coupling (reciprocal relationship) of the dogs (developmental processes) to their owner (genes) over time can the various contributors to evolutionary change be more sufficiently represented (Kevin N. Laland et al., 2013; Kevin N. Laland et al., 2015).

It is worth noting that beyond the most recent calls for for an EES, launched predominantly from within evolutionary developmental biology (or affectionately known as "evo-devo"), and beneath the highest profile debates between opposite ends of the MS theoretical spectrum (for example, the popularised debate between E.O. Wilson and Richard Dawkins over the generalisability of kin selection and/or multilevel (group) selection), consistent and productive attempts have been made by evolutionary biologists to integrate the system dynamics of evolutionary processes into empirical research programs (Wray et al., 2014; Svensson, 2017). Beginning with Fisher's initial attempts to account for the reciprocal dynamics of sexual selection on gene frequencies in initial mathematical formulations of the MS (**Fisher1930**), there have been numerous attempts to either empirically measure or mathematically model bidirectional causation in evolutionary processes. Such attempts can identified in areas such as coevolution (SOURCE), frequency-dependent selection (**Prum2010**), sexual selection (**Svensson2009**), sepciation (**Mayr1965**), and canalisation (**Waddington1950**). As I will discuss in more detail below, the bidirectional causation of evolutionary processes is particularly relevant to human evolution, and has been modelled in relation to human social evolution in coalition formation and cooperative networks (**Gavrilets2008**), as well as in approaches that attempt to model the interaction between biological and cultural systems of transmission (**Cavalli-Sforza1989**; Cavalli-Sforza & Feldman, 1981;

Boyd & Richerson, 1988; N. Henrich & Henrich, 2007; Claidière & Sperber, 2007). Reciprocal causation is also central to the field of "eco-evolutionary dynamics," in which the bidirectional feedbacks between ecological (demographic, social, spatial) and evolutionary processes (genetic change within populations) are modelled, particularly in instances in which ecological and evolutionary timescales converge (**Hendry2017**). While the EES represents the most recent and vocal critique of the narrowest assumptions and protocols of the MS, it is important to recognise that consistent empirical progress is being made within the existing parameters of the MS. Indeed, many evolutionary biologists insist that the predictions of the MS are robust and resilient enough to endure continued innovation and modification, including the incorporation of nonlinear dynamics, without the need for an "extension" (Wray et al., 2014; Lewens, 2017; Svensson, 2017).

Despite these areas of theoretical contentions, almost all evolutionary theorists now agree on the point that the only way to progress evolutionary approaches to knowledge beyond theoretical advocacy, is to initiate methodologically innovative empirical research programs designed to test and expand the predictions of both the MS and EES, whether or not they constitute the same or separate scientific paradigms. In particular, this includes utilising methods capable of quantifying (and qualifying) reciprocal causation in both micro and macro evolutionary processes (Wray et al., 2014; K. Laland et al., 2014; Kevin N. Laland et al., 2015; Svensson, 2017). As I will explain below (section X), the social cognition of joint action is a research domain rich in methodological and empirical opportunities, and in which key knowledge gaps in evolutionary approaches to behaviour (particularly approaches to human behaviour) can be addressed.

1.3.2 Cognitive and evolutionary approaches to human behaviour

In this section, I review the application of MS approaches to human behaviour in order to assess their usefulness in an explanation of group exercise. The phenotypic niches of many organisms involve interactions between complex social, ecological, and spatial dimensions made up of social partners, other species, and environmental fluctuations over over various timescales. The human evolutionary niche appears to be distinct, however, in that it entails species-unique capacities for complex manipulation of extra-somatic materials (producing artefacts ranging from stone tools to quantum computing), information rich, malleable and scalable communication systems (producing syntactically complex language), and physiological, psychological, social affordances of shared cultural practices (producing phenomena such as ritual and religious activities). Importantly, the distinctiveness of the human evolutionary trajectory, identifiable in its various biological, technical, and cultural productions, appears to be fundamentally contingent upon processes of bidirectional causation between proximate developmental processes and ultimate evolutionary consequences. As I will outline below, however, most applications of MS to human behaviour remain constrained by evolutionary models— borrowed originally from population genetics and evolutionary biology—that adhere relatively closely to a narrow neo-Darwinian conceptions of evolutionary processes (Claidière, Scott-Phillips, & Sperber, 2014; Mesoudi, 2017). The theoretical tensions and methodological challenges of the MS paradigm outlined above are thus particularly salient when dealing with evolutionary explanations of human behaviour.

Initial attempts to use the MS paradigm to account for the the complexity of the human evolutionary niche proposed that humans' species-unique behavioural capacity for what is traditionally broadly construed as "culture," resembles an evolutionary system in its own right—distinct from (albeit contingent upon) biological evolution. Initial MS approaches to human behaviour thus began with the recognition that the processes associated with population-level transmission, accumulation, and fixation of cultural variants (cultural practices, norms, languages, etc) were similar in many ways with processes of biological evolution, and should therefore be modelled as such.

Proximate-ultimate:

Culture is either a proximate mechanism: a phenotypic affordance that enhances fitness benefits (Dawkins, 1982)

Or alternatively Gene culture co-evolution or dual inheritance

Or alternatively culture as niche construction (Fuentes2016).

The strictest versions of MS approaches to human cultural evolution proposes the "meme" as a gene-like unit of cultural information, which, like a gene, is subject to selection pressures of replication. Memes that successfully replicate successfully populate(Dawkins, 1976). Beyond the strict meme approach to cultural transmission, models of cultural evolution adjust population genetic models to take into account the observable differences between cultural and genetic information, such as culture's capacity to support one-to-many transmission, the blending of cultural variants, and non-randomly guided variation (Cavalli-Sforza & Feldman, 1981; Boyd & Richerson, 1988). These adjustments are part of the concession that that cultural variants are not as dependent on high fidelity replication as their genetic cousins, but instead are shaped by evolved cognitive biases that favour the acquisition and transmission of some cultural variants over others due to their memorability or effectiveness (N. Henrich & Henrich, 2007).

Theories of cultural evolution thus direct attention towards the role of cognitive mechanisms of imitation, teaching, and memory, in enabling high fidelity copying (with occasional mutation-like errors) of cultural variants between individuals and throughout populations, with distributions stable enough for selection to operate. Models indicate that for social learning to actually enhance population fitness, it must be cumulative throughout generations, i.e., individuals must be able to socially learn what they could not learn on their own (Robert Boyd & Richerson, 1995). Thus, particular attention has been paid to the mechanisms that could be responsible for facilitating species-unique *cumulative* culture (M. Tomasello, 2008). Evidence from comparative and developmental psychology indeed appears to confirm that a precocious and species-unique tendency to accurately imitate the actions of trusted or authoritative others (even when the goal of the action is unclear) sets the cognitive foundation for the transmission of cultural representations (Michael Tomasello, 2014b).

Analysis of microevolutionary processes of cultural transmission have been enhanced by supplementing macro-evolutiony processes, also known as cultural phylogenetics (Mace & Pagel, 1994). The phylogenetic comparative method seeks to understand long-term cultural change at or above the level of the society by 1) reconstructing the cultural evolutionary history of a particular trait or set of traits and 2) testing functional hypotheses concerning the spread or distribution of cultural variation across societies while controlling for evolutionary history. The combination of these micro- and macroevolutionary approaches to human behaviour supports the theory that "dual-inheritance" or "co-evolution" of genetic and cultural information in humans over time has led to a diverse range of capacities ranging from behaviours as lactose tolerance in adult populations (Feldman & Cavalli-Sforza, 1989), to a "norm-psychology" thought to underwrite prosocial behaviours and institutions that facilitate collective adherence to shared cultural practices (Richerson & Boyd, 2008; Chudek & Henrich, 2011).

1.3.2.1 Cultural Attraction

There is evidence to suggest that, beyond microevolutionary mechanisms of transmission, other factors may also have an important causal impact on the accumulation and distribution of cultural variants. Whiten Whiten (2000) demonstrates in the case of non-human primates that cultural knowledge may not necessarily accumulate via strict imitation or copying, but also from affordances of social-ecological niches.

In this sense, the "ratchet" of human culture may be contingencies that have accumulated within the evolutionary trajectory of the species over long periods of time, such as niche construction (Odling-Smee, Laland, & Feldman, 2003), canalisation of selection initiated by phenotypic plasticity (Godfrey-Smith, 2017), and other forms of non-genetic inheritance (Lewens, 2017). Demographic factors such as population size, structure, and interconnectedness have been shown to determine cultural complexity (variation) in hunter gatherer populations, with adaptive implications (J. Henrich, 2004). It has also been suggested that variation in prosociality, social bonding, and social cohesion could have an important bearing on information transfer between individuals and within groups (Heyes, 2011; Whitehouse, McQuinn, Buhrmester, & Swann, 2014; Wheatley & Sievers, 2016). As researchers in comparative and social psychology have pointed out, humans do not merely aggregate, but rather actively congregate around shared cultural practices, seemingly driven by species-unique affective and motivational mechanisms(Dunbar & Shultz, 2010; Michael Tomasello, Carpenter, Call, Behne, & Moll, 2005). In addition, there is evidence of cross-cultural variation in the microevolutionary dynamics of cultural evolution, for example, with specifically higher social learning in collectivistic East Asian societies than in individualistic Western societies (Mesoudi, Chang, Murray, & Lu, 2015; DiYanni, Corriveau, Kurkul, Nasrini, & Nini, 2015).

In light of this collection of evidence, researchers have sought to broaden the scope of cultural evolution by relaxing the strictly selectional logic of memetic and dual-inheritance models, instead suggesting that cultural variants will tend locally towards certain "attractor points" depending on the diverse cognitive, demographic, ecological factors of attraction to which they are subjected (Sperber, 1996). Rather than explaining patterns of cultural diversity, stability, and change in terms of the differential selection of certain cultural variants (e.g., content biases) or differential copying of certain individuals (e.g., success bias, prestige bias), "cultural attraction theory"(CAT) focuses on how cultural variants are systematically *re-produced* by a combination of frequency dependent (i.e. conformity) and context sensitive (i.e. prestige) transmission biases, as well as the biophysical, psychological, historical, and ecological dynamics by which these biases are constrained and directed (Claidière et al., 2014). It has been pointed out that in contrast to genetic evolution, the mechanisms responsible for transmitting cultural information in humans (imitation, learning, and memory) cannot alone explain population level stabilisation of cultural variants, because they are not faithful enough to stabilise distributions of cultural variants on which selection can operateClaidière et al., 2014. CAT suggests instead that population level cultural variation is produced by processes that are partly preservative (i.e., occur via mechanisms of transmission), and partly re-constructive—the combination of which will result in cultural variants that tendentially converge upon particular types, called attractor points.

The problem with these approaches: 1.Selection-focussed, replication focussed (copying)

The interactive and affective mechanisms of shared cultural practices (i.e., the unmistakably "visceral" dimension referenced above) appear, phenomenologically at least, to be of distinct relevance to processes of cultural information transfer, and thus require careful and considered incorporation into a theory of cultural transmission.

Just as MS theories of biological evolution tend to under-account for nonlinear systems-level causal processes involved in biological evolutionary change, theories of cultural evolution suffer from the under-theorisation of complex cognitive, social, and ecological processes (in addition to imitation and selection) that collude to shape the evolutionary trajectory of cultural representations (Mesoudi, 2017).

Two key challenges inherent in accounting empirically for human behaviour, therefore, are the process of drawing out the the *biological* details inherent in cultural transmission on the one hand, and drawing out the *cultural* details of biological evolution on the other (Claidière et al., 2014; Fuentes & Wiessner, 2016).

This original manoeuvre of transferring MS theories of biological evolution to the modelling of "culture" carried with it the same theoretical tension inherent in MS applications to biological evolution discussed above. COMPUTERS!

2.

1.4 Cognitive and evolutionary approaches to Group Exercise

Physical activity, exercise, and sport have well-known positive effects on psychological and physical health (Ekkekakis, 2003; Fiuza-Luces, Garatachea, Berger, & Lucia, 2013). Social scientists have also long speculated about the benefits of energetic group activities such as ritual, music, and dance for social cohesion (Durkheim, 1965). Group exercise contexts typically require the coordination of both movement and intentions (Reddish, Fischer, & Bulbulia, 2013), which together activate neurobiological mechanisms implicated in social reward (Dunbar, 2010; Eisenberger, 2012), as well as those involved in enduring the pain and discomfort of physiological exertion, i.e., the "runner's high" (Boecker et al., 2008; Dietrich & McDaniel, 2004; Sullivan, Rickers, & Gammage, 2014). While the physiological, psychological, and social processes that combine in instances of exerted, coordinated movement are rich and varied, existing evidence pertaining to the immediate causal triggers of group exercise suggest a link between group exercise and social cohesion (Davis, Taylor, & Cohen, 2015; Emma Cohen, 2017). It is now understood that strenuous and prolonged physical exercise is modulated by the same neuropharmacological systems (namely, the opioidergic and endocannabinoid systems) responsible for regulating pain, fatigue, and reward (Boecker et al., 2008; Raichlen, Foster, Seillier, Giuffrida, & Gerdeman, 2013). Exercise-specific activity of these systems offers a plausible neurobiological explanation for commonly reported sensations of positive affect, anxiety reduction, and improved subjective well-being during and following exercise—extremes of which asre popularly referred to as the “runner’s high” (Dietrich McDaniel, 2004; Boecker et al. 2008; Raichlen, Foster, Gerdeman, Seillier, Giuffrida, 2012). Meanwhile, research in social psychology focusing on the relationship between time-locked behavioural synchrony and processes of self-other merging, social alignment, and affiliation has shed light on the social and affective significance of interactive and coordinated movement typical of many group exercise contexts Wiltermuth and Heath, 2009; Kirschner and Tomasello, 2010; Reddish, Fischer, and Bulbulia, 2013; Tunçgenç and Cohen, 2016. Experimental evidence suggests that time-locked coordination of behaviour between two or more individuals in the stable attractor/equilibrium states of either in-phase or anti-phase synchrony is conducive to psychological processes of self-other merging, liking, trust and affiliation. It is believed that lower cognitive processes of joint attention mediate the link between synchrony and social bonding, with synchronised activity (common in music, dance, and some sports) providing a shared spatio-temporal (and often haptic) referent around which to coordinate attention and behaviour Launay, Tarr, and Dunbar, 2016; Wolf, Launay, and Dunbar, 2016.

This neuropharmacological account of group exercise and social bonding has its roots in studies of social grooming in non-human primates. Dunbar and colleagues propose a neuropharmacologically mediated affective mechanism linking dyadic grooming practices with group-size maintenance (Machin & Dunbar, 2011). The capacity for social cohesion is thought to have arisen in primates as an adaptive response to the pressures of group living. Aggregating in groups serves to reduce threat from predation. At the same time, it can be individually costly due to stress arising from interaction at close proximity and conflict over resources among genetically unrelated individuals. These pressures are hypothesised to have led to selection for social bonding (e.g., via dyadic grooming). Resulting coalitional alliances among close partners allow for the maintenance of the group by buffering the stresses of group living. Primate social grooming, for example, is associated with the release of endorphins, presumably leading to sustained rewarding and relaxing effects. While other neurotransmitters such as dopamine, oxytocin, or vasopressin may also be important in facilitating social interaction, endorphins allow individuals who are not related or mating to interact with each other long enough to build "cognitive relationships of trust and obligation" (Dunbar, 2012, p. 1839). It is thought that, as the homo genus evolved more complex collaborative capacities for survival in interdependent group contexts, grooming-like behaviours sustained social bonding in larger groups where dyadic grooming would cumulatively take too much time (Dunbar, 2012). Experimental studies suggest that neurophysiological mechanisms activated by activities that involve physical exertion and coordinated movement, such as group laughter, dance and music-making, exercise, and group ritual can bring groups closer together, mediated by the psychological effects of endogenous opioid and endocannabinoid release (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2009; Fischer et al., 2014; Fischer & Xygalatas, 2014; Sullivan, Rickers, & Gammage, 2014; Bronwyn Tarr, Launay, & Dunbar, 2016; Tarr, Launay, Cohen, & Dunbar, 2015).

Recently, anthropologists have attempted to integrate analyses of ethnographic, archaeological, and phylogenetic information in order to develop broader theories of social cohesion. Drawing initially from ethnographic observations of ritual practice in the Papua New Guinean Highlands, Harvey Whitehouse developed a general theory of human social cohesion based on two divergent modes of ritual practice and their associated psychological and sociopolitical effects (Whitehouse, 1996). High-frequency, low-arousal religious rituals (weekly attendance at church sermon, praying, etc.) are associated with identification with the prototypical features of the group ("group identification") whereas low-frequency, high-arousal rituals (tribal initiation rituals, dysphoric experiences such as frontline combat) generate "identity fusion"—a visceral feeling of oneness with the group.

Whereas group identification can be understood as a psychological adaptation deriving from a norm coalitional cooperative mechanisms, identity fusion arises from the generalization of kin-detection mechanisms, whereby individuals recognize others with whom they have shared core self-defining experiences as "fictive kin." Whitehouse and colleagues (2014) argue that these two distinct psychological states, and the ritual practices that reliably generate such states, represent "attractor positions" in the cultural evolution of religion and human sociality. In a return to Durkheim's original outlay for the study of social cohesion, the modes theory incorporates the two key underpinning mechanisms of social cohesion (i.e., cumulative culture and its interaction with human capacities for social bonding) by accounting for variance both in the modes of shared cultural practices and in the emotional quality of group-level commitment. In his study of religion, prosociality, and extreme altruistic behavior, Scott Atran similarly insists on the need to carefully consider the interaction between cultural, cognitive, and affective mechanisms, in particular the role of communal rituals in "rhythmically coordinat[ing] emotional validation of, and commitment to, moral truths" (Atran and Norenzayan 2004, 714). Atran suggests that extreme altruism can be explained only by considering the codependent relationship between the affective motivational processes (of arousal, pain, and reward) and the cultural representations ("sacred values" of the group) with which these psychophysiological mechanisms interact and become associated.

Relatedly, recent empirical studies of extreme ritual practice present evidence of a positive relationship between pain experienced during high ordeal rituals (e.g., walking on hot coals) and subsequent expressions of parochial prosociality. Interestingly, in contrast to the prevailing adherence to multilevel selection and cultural-group selection theories of social cohesion, these researchers speculate that the selective advantages available in extreme group ritual are afforded primarily to the individual (e.g., moral cleansing, improvements in social standing), with group-level benefits arising only secondarily (Fischer and Xygalatas 2014). In so doing, Fischer and Xygalatas, for example, centralize the explanatory role of proximate psychological mechanisms (of arousal, pain, and reward) in establishing and maintaining social cohesion.

Studies linking synchrony with social bonding and cooperation are supported by a literature than connects nonconscious mimicry with liking and affiliation(van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009). The experimental studies above predominantly refer to dyad synchronisation of behaviour. The social and psychological effects of group level synchronisation have been harder to induce and measure in experimental settings. However, in addition to in- and anti-phase behavioural matching, group synchronisation may be subject to more complex and dynamical processes of coupling, which could entail specific psychological consequences. This also appears to be true in cases of joint—but not necessarily explicitly synchronised—action, whereby implicit processes of movement regulation link two or more individuals in a complex and dynamic coupling. The variation and stabilisation of such dynamic couplings could have psychological effects (see (**Marsh2009a**; Richard C. Schmidt & Richardson, 2008)). Most encouraging is evidence that manages to integrate the social and neurophysiological dimensions of group exercise. Recent experimental evidence suggests that social features of the exercise environment (for example, perceived social support, level and quality of behavioural synchrony, etc.) modulate exercise-induced mechanisms of pain, and reward (Cohen et al., 2009; Sullivan et al., 2014; Tarr et al., 2015; Davis et al., 2015; Weinstein, Launay, Pearce, Dunbar, & Stewart, 2016). This work is bolstered by existing literature on the social modulation of pain (Eisenberger, 2012) and links between pain and prosociality (Bastian, Jetten, & Ferris, 2014).

In addition to reports of exercise-induced euphoria and positive affect, adherents to (group) exercise and other activities—particularly highly skilled practitioners—also commonly report experiencing states of "optimal" or "peak" performance, which include feelings of heightened focus, personal transcendence, time-warp (the experience of time either speeding up or slowing down), spontaneity, creativity, and effortlessness (S. A. Jackson, 1995). "Flow," as this particular cluster of states has commonly been referred to, is a powerful, autotelic and embodied experience, which combines components of both "hedonic" (sensation-centred, see (Huta & Ryan, 2010)) and "eudaimonic" (meaning-centred, see Carol D. Ryff, 1989; Carol D Ryff, 2015) dimensions of subjective well-being, and is theorised to emerge when activity strikes a balance for the individual between challenge and skill requirements (Csikszentmihalyi, 1990; Abuhamdeh & Csikszentmihalyi, 2012). At the level of the group, the "team click" and "group flow" are highly elusive possibilities, coveted by athletes, coaches, and fans alike (Novak, 1993; Sawyer, 2006). While the experience of flow associated with prolonged exercise may be in part neuropharmacologically mediated by the opioidergic and endocannabinoidergic systems, phenomenological accounts suggest that there is something distinct about the experience of flow in exercise that requires a more complete cognitive and social explanation (A. Dietrich, 2006; A. Dietrich & Audiffren, 2011). One speculative neurocognitive account of acute exercise, for example, suggests that the metabolic costs associated with complex or prolonged regulation of movement forces an energetic trade-off in the brain in which lower level neurocognitive processes win out, forcing a down-regulation of the pre-frontal areas of the brain (A. Dietrich & Audiffren, 2011). Dietrich and colleagues propose that the down-regulation of cortical processes induces a decline in executive control (Labelle, Bosquet, Mekary, & Bherer, 2013) and possibly dampens self-monitoring and personal agency. If this hypothesis is correct, it is highly plausible that flow and its neurocognitive underpinnings are relevant to the affective and prosocial effects of group exercise.

It is also apparent that group exercise contexts offers to its participants and observers an opportunity for profound meaning. Many people do not engage in exercise just for health or enjoyment; rather, in some contexts it forms part of a life of meaning, purpose, and self-discovery (see for example Jackson, 1995; Jones, 2004; White & Murphy, 2011). Modern sport has always been much more than "just a game", and instead offers an arena in which virtues and vices are learned, and the "morality plays"—of community, national, and globe—thus performed (Elias & Dunning, 1986; McNamee, 2008). Ethnographic perspectives on group exercise contexts emphasise the ethical and moral dimensions of athletes' experiences, and contextualise these experiences within political processes relating to the construction of the self, community, and nation-state (Alter, 1993; Brownell, 1995; Downey, 2005b; Wacquant, 2004). Athletes who engage in extremely physiologically costly exercise, particularly at the elite apex, often report the autotelic experience of "flow"—described as full immersion in the "here and now," effortlessness, or optimal experience (Csikszentmihalyi, 1992; Dietrich, 2004). At the level of the group, "team click" and "group flow" are highly elusive possibilities, coveted by athletes, coaches, and fans alike (Novak, 1993; Sawyer, 2006). The complexity of motivation for exercise presented both ethnographically and anecdotally presents an opportunity for further research into the cognitive, evolutionary, and social mechanisms that produce participation and adherence to exercise, particularly in contexts in which exercise is extremely costly.

4. What about an EES approach to GE, in order to model the vitality of the activity? 5. Possible reconciliation between MS EES? 6. Target Phenomenon: team click 7. The Present study 1. Beijing Men's rugby team 1. Rugby as joint action context 2. Cultural variation: China group membership 2. Methods 1. Ethnography 2. Survey 3. Controlled experiment 3. Results 4. Discuss relevance 8. Contributions of thesis 1. Novel theoretical framing 2. Mixed methods (first ethnographic application of these theories?) 3. Cross-cultural dimension 4. Novel evidence linking joint action and social bonding in a real world context 5.

1.5 What is the path forward for MS approaches (to Group Exercise)?

1.5.1 Emerging possibilities

Currently, candidates for such quantification include computational modelling techniques,

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Coordination dynamics (Kelso).

1.5.2 Active inference and functional interpersonal synergies

A combination of recent advances in neuroimaging technologies (C. Frith, 2007), emerging neurocomputational theories of brain function (Friston, 2010; U. Frith & Frith, 2010; Clark, 2013), and constructive attempts to extend the theoretical paradigm of human social cognition to account for inter-individual processes of interaction and coordination (Sebanz et al., 2006; Dale, Fusaroli, Duran, & Richardson, 2014), has created an opportunity to examine in finer-grained detail the relationship between coordinated and exertive group activities and social cohesion. It is now more clearly understood that basal human capacities for physical movement regulation and coordination set the foundation for social cognitive systems whose resources are distributed between brains, bodies, and physical features of task-specific environments (Hutchins, 2000; Kirsh, 2006; G. Semin & Cacioppo, 2008; Gün R Semin, Garrido, & Palma, 2012; Coey, Varlet, & Richardson, 2012). Human cognition appears to be driven by a processes of "active inference" (Friston, 2010) about the world. Agents generate top-down interoceptive predictions about the state of the world and test these representations against bottom-up sensory evidence (Clark, 2013). In this account, perception, representation, emotion, and action are unified by the logic of prediction-error management, and neurocognitive components interact to align the organism with its expectations (Pezzulo, 2014). Conceiving of social cognition in this way, as an embodied, embedded, and immediate process of inference, centralises the role of automatic movement regulation strategies—traditionally classed as "lower-cognitive" processes—in establishing and maintaining the transfer of cultural information between individuals, within groups, and throughout populations—traditionally thought to be executed by "higher-cognitive" processes (Claidière et al., 2014).

Literature suggests that successful joint action in humans is contingent on the ability to share functionally equivalent task representations. Considering the cognitive principles of "active inference" referenced above, shared task representation amounts to minimising prediction error in social cognitive systems involving two or more co-actors (G. Semin & Cacioppo, 2008; U. Frith & Frith, 2010). Humans appear to employ an array of explicit and implicit behavioural strategies in order to achieve this. The ways in which co-actors "close the loop" (C. Frith, 2007) on joint action through deliberate ostensive communication has been the traditional focus of developmental, comparative Michael Tomasello et al., 2005, and social psychologists (Sebanz et al., 2006). More recently, however, analysis of dynamic coupling of co-actors in joint action scenarios reveals that synchronised movement implicates an array of implicit and pre-perceptual cognitive processes of alignment and prediction error minimisation (R. C. Schmidt, Fitzpatrick, Caron, & Mergeche, 2011), which, in addition to more explicit forms of communication, could be central to the generation of feelings of self-other merging, self-other distinction, and perceived reliability and trust associated with social bonding (Marsh et al., 2009). By interrogating the ways in which component mechanisms and system dynamics of joint action generate social bonding, this dissertation seeks to offer a novel contribution to the cognitive and evolutionary anthropology of social cohesion.

There is something unmistakably visceral about human behavioural phenomena in which group exercise features, and this powerful impression of "vitality" associated with group exercise may be due to the the nonlinear system dynamics associated rigorous and coordinated physical movement (Kelso, 2016). In this dissertation, I suggest that the social cognition of joint action provides a research domain in which predictions pertaining to bidirectional causation in micro- and macro-evolutionary processes (now associated with the EES), can be integrated alongside more traditional predictions of the MS. Anthropology provides diverse methodological and theoretical toolkits make anthropology well positioned to contribute to the advancement of explanations of biological life (Cohen, 2010; Fuentes & Wiessner, 2016). In the case of the social cognition of joint action, a range of useful techniques, ranging from qualitative ethnography, controlled field and laboratory experiments measuring individual-level psychophysiological response (Cohen, 2010), game theoretical modelling (Turchin, Currie, Turner, & Gavrilets, 2013; Nowak, Vallacher, Zochowski, & Rychwalska, 2017), as well as emerging techniques capable of quantifying nonlinear systems dynamics of human movement (Kelso, 2009), are all available to the anthropologist. Given the practical parameters of this particular dissertation, I employ ethnographic and field experimental methods, and identify methods for quantifying nonlinear dynamics in joint action as important for future research in this field (Richardson, Schmidt, & Richardson, 2008; Marsh et al., 2009).

A combination of recent advances in neuroimaging technologies (C. Frith, 2007), emerging neurocomputational theories of brain function (Friston, 2010; U. Frith & Frith, 2010; Clark, 2013), and constructive attempts to extend the theoretical paradigm of human social cognition to account for inter-individual processes of interaction and coordination (Sebanz et al., 2006; Dale et al., 2014), has created an opportunity to examine in finer-grained detail the relationship between coordinated and exertive group activities and social cohesion. It is now more clearly understood that basal human capacities for physical movement regulation and coordination set the foundation for social cognitive systems whose resources are distributed between brains, bodies, and physical features of task-specific environments (Hutchins, 2000; Kirsh, 2006; G. Semin & Cacioppo, 2008; Gün R Semin et al., 2012; Coey et al., 2012). Human cognition appears to be driven by a processes of "active inference" (Friston, 2010) about the world. Agents generate top-down interoceptive predictions about the state of the world and test these representations against bottom-up sensory evidence (Clark, 2013). In this account, perception, representation, emotion, and action are unified by the logic of prediction-error management, and neurocognitive components interact to align the organism with its expectations (Pezzulo, 2014). Conceiving of social cognition in this way, as an embodied, embedded, and immediate process of inference, centralises the role of automatic movement regulation strategies—traditionally classed as "lower-cognitive" processes—in establishing and maintaining the transfer of cultural information between individuals, within groups, and throughout populations—traditionally thought to be executed by "higher-cognitive" processes (Claidière et al., 2014).

A review of the available literature suggests that successful joint action in humans is contingent on the ability to share functionally equivalent task representations. Considering the cognitive principles of "active inference" referenced above, shared task representation amounts to minimising prediction error in social cognitive systems involving two or more co-actors (G. Semin & Cacioppo, 2008; U. Frith & Frith, 2010). Humans appear to employ an array of explicit and implicit behavioural strategies in order to achieve this. The ways in which co-actors "close the loop" (C. Frith, 2007) on joint action through deliberate ostensive communication has been the traditional focus of developmental, comparative Michael Tomasello et al., 2005, and social psychologists (Sebanz et al., 2006). More recently, however, analysis of dynamic coupling of co-actors in joint action scenarios reveals that synchronised movement implicates an array of implicit and pre-perceptual cognitive processes of alignment and prediction error minimisation (R. C. Schmidt et al., 2011), which, in addition to more explicit forms of communication, could be central to the generation of feelings of self-other merging, self-other distinction, and perceived reliability and trust associated with social bonding (Marsh et al., 2009). By interrogating the ways in which component mechanisms and system dynamics of joint action generate social bonding, this dissertation seeks to offer a novel contribution to the cognitive and evolutionary anthropology of social cohesion.

1.5.3 General predictions

1.6 The present Study

1.6.1 Team Click, Joint Action, and Social Bonding

There is considerable variation in the nature and dynamics of joint action, even within the sub-category of group exercise. Joint action in group exercise ranges from tightly coupled dyadic or group activities such as rowing, synchronised diving, or dance sport, to interactive competitive team sports like basketball, ice hockey, and rugby, through to more loosely coupled (but still time- and space-coordinated) mass participation activities such as marathons and triathlons. It is sensible to assume that, as the scale and requirements of these contexts vary, so too will the psychophysiological mechanisms most responsible for enabling successful joint action, feelings of team click, and social bonding (Mogan, Fischer, & Bulbulia, 2017; Launay et al., 2016).

Interactive and co-active team sports in particular contain dimensions of complexity that are not directly addressed by the existing experimental literature concerning synchrony or joint action. The competitive nature of these sporting practices means that co-actors in joint action scenarios will perform roles that either facilitate or obstruct shared goal achievement, depending on team assignment (Renshaw, Davids, Shuttleworth, & Chow, 2009). Competitive joint action scenarios facilitate two modes of communication between individual participants: more predictable behaviour between cooperators and less-predictable action behaviour between opponents (Glover & Dixon, 2017). Thus the competitive dimension of interactive team sports introduces complexity, whereby subunits of cooperating co-actors coordinate their behaviours around a shared goal (winning the specific contest) (Passos, Cordovil, Fernandes, & Barreiros, 2012), and co-actors from both teams coordinate with each other around the higher order shared goal of completing a competitive game. In addition, interactive team sports involve the nesting of coordinated subunits of actors and sub-phases of actions (Vilar, Araujo, Davids, & Button, 2012). For example, a dyadic joint action such as passing a ball between two attacking players in association football is nested within a larger attacking sub-phase goal of advancing towards the opposing team's goal in order to score a goal, which is in turn nested within a larger shared goal of beating the opposing team in a 90 minute match, and so on. These dimensions of complexity in interactive team sports increase the overall degrees of freedom of joint action tasks, thus demanding higher technical competence in order to successfully establish functional interpersonal synergies capable of reducing such uncertainty and behaving adaptively (Duarte, Arajo, Correia, & Davids, 2012).

In addition to micro-level details and dynamics of joint action, macro-level variation in the cultural contexts of joint action also vary extensively. Importantly, macro-cultural expectations appear to frame and direct micro-level movement dynamics of joint action. As sporting anecdote indicates, different teams from different places and times appear to play the same game in very different ways—embodying different "styles" of play. While there is very little literature devoted to examining the effect of cultural variation on joint action and social bonding in particular, there is extensive evidence to suggest that cultural variation impacts on processes of cognition (Nisbett, 2003; Hoshino-Browne et al., 2005), social learning (Mesoudi et al., 2015), and prosocial behaviour (Yuki, Maddux, Brewer, & Takemura, 2005; Yuki, 2003). It has been suggested that cultural environments structure joint action scenarios in ways that help "smooth" coordination by providing equivalent expectations between co-participants (Vesper et al., 2017). Indeed, as anecdote and observations concerning suggest, perception of "team click" is not necessarily limited to the most proximal dimensions of joint action perception, but is rather contingent on the snug fit between a given joint action and a whole assemblage of hierarchically ordered expectations.[1]

1.6.1.1 Rugby Union in China

The empirical content of this dissertation is drawn from on one contemporary instance of group exercise, in one geographic region. Rugby union football and the People's Republic of China are subjects not commonly heard uttered in the same breath or pictured in the same sentence. Nonetheless, the Olympic status of rugby union, and the deep Olympic logic of the state-sponsored Chinese sports system, means that today hundreds of professional Chinese rugby players are meaningfully engaged in one of the world's most physiologically strenuous interactive team sports. During a two year period between August 2015 and September 2017, I spent three separate periods in China during which time I conducted a total of 10 months of ethnographic research with the Beijing Men's Provincial Rugby Team. I then extended this ethnographic analysis by conducting as two field studies, for which I sampled from a broader population of professional Chinese rugby players from 9 different provinces.

[1] It is also important to bear in mind that, while the neurological, cognitive, and psychological theories from which the predictions of this dissertation strive for universal generalisability, these theories are nonetheless heavily grounded in Western epistemological assumptions, intuitions, and "WEIRD" empirical evidence (J. Henrich, Heine, & Norenzayan, 2010).

Between August 2015 — March 2016, I spent seven months in Beijing engaged in participant observation and conducting unstructured and semi-structured interviews, and informal surveys with the Beijing Men's Rugby Team. Between July — August 2016 I returned to China for a further two months, during which time I continued ethnographic observations of the Beijing team, while also conducting two pseudo-experimental field studies spanning two other locations, Hebei province and Shandong province. Finally, I spent one month in Beijing and Tianjin between August — September 2017 during which time I conducted follow-up structured interviews the with 10 athletes who participated in the Chinese National Games, as well as follow up informal interviews with athletes from the Beijing Men's Rugby Team.

1.6.1.2 Physical culture and sport in China

Throughout China's modern history, a rich indigenous physical culture merged with modern waves of cultural importation beginning in the mid 19th Century. Modern sport and exercise was first introduced to China as part of the "New Culture Movement" at the start of the 20th Century——a movement in which student intellectuals problematised traditional Daoist and Confucian understandings of the body as "passive" and "feudal," and suggested that a new, active and competitive body, should be realised (Ge & Song, 2005). Spenserian ideology celebrated the cultivation of the physical body as foundational to the cultivation of the modern Nation-State (Morris, 2004). In this vein, the passive and weak Chinese body of the feudal past was publicly identified by student intellectuals and nationalist political movements as the cause of the China's collective weakness as it grappled with colonialism in the early 20th century. In its place, a strong, masculine, and active body as was established as a central public representation of China's bright future (Brownell, 1995), see Figure **??**). As such, towards the end of the 19th century, traditional practices of self-cultivation such as the Daoist notion of "cultivating life" (*yangsheng zhidao*), which included traditional martial practices of taichi and qigong, were denounced by reformers in favour of a variety of imported physical regimes and an associated philosophy of "training the body" (*duanlian shenti* , see Farquhar and Zhang, 2012).

1.6.1.3 Rugby Union Football

Rugby Union (hereafter rugby) is an interactional team sport played on a rectangular field (100m x 70m), by two teams, usually of 15 players, who physically contest possession of an egg-shaped ball that can be used to score points (IRB, 2014).[2] "Rugby sevens" (hereafter Sevens), the version of rugby that is the focus of this research, is a shorter 7-on-7 version of rugby. Sevens is a highly interactive and physiologically demanding sport at all levels at which the game is currently played, even more so than the 15-a-side version of the game. Sevens requires players to participate in frequent bouts of intense (anaerobic) activity such as sprinting, physical collisions, tackles, and grappling, separated by short bouts of low intensity activity such as walking and jogging. Sevens requires high levels of interdependence between team members due to the uncertainty and complexity of interactive coordination tasks. At the elite level in particular, the physiological costs and complexity of joint action requirements of sevens are amplified.

There is evidence to suggest that dynamic coupling occurs between dyads and sub-units of attack and defence in rugby (Passos et al., 2011; Correia et al., 2014). Passos and colleagues Passos et al. (2011) for example find that functional coupling tendencies emerge between attacking dyads and adapt to specificities of the task environment. Correia and colleagues Correia et al. (2014) show that coupling tendencies also emerge between co-actors of opposing teams in rugby, for example, in a 1-on-1 attacker/defender sub-phase. These results are confirmed in similar joint action contexts in other equivalent sports such as basketball and association football (Duarte et al., 2013). There is evidence to suggest that the establishment and maintenance of functional interpersonal synergies in rugby joint action depend on an athlete's perception of affordances of the task-specific cognitive system made up of constraints including other athletes, the physical environment, and the rules of the game (Passos et al., 2012).

Very little direct empirical evidence specific to rugby can be used to substantiate a link between joint action and team click, and team click and social bonding. Rugby is, however, a sport heavily associated with "social bonding" in the more popular discursive sense, particularly in all-male social organisation common in the elite educational institutions of England and Commonwealth countries in which rugby

[2]Descending from a variety of locally-specific folk-games played in pre-industrial England, all loosely grouped as "football", rugby developed within the elite public school system as a deliberate physical activity arbitrated by rules and regulations, before circulating through the arteries of England's colonial empire as a leisurely pastime—a "sport" (Dunning & Sheard, 2005).

originally developed (Dunning & Sheard, 2005; Richards, 2007; Collins, 2008).[3] "Rugby is a game for barbarians played by gentlemen," or so the saying goes.[4]. Different inflections on this adage have been reproduced by people in all parts of the world that rugby has reached (including China), presumably as a way of linking the nature of rugby's physical requirements with social virtues of fair play, cooperation, and moral integrity. Although direct experimental evidence concerning rugby is scant, the physiological demands, joint action complexity, and social-historical trajectory of rugby suggests that it is extremely suited to an investigation of the social bonding effects of joint action in group exercise.

1.6.2 Study Predictions

1.6.3 Empirical Studies

1.6.4 Results

1.7 Thesis Contributions

1.8 Chapter Summary

[3]Rugby union has been the site of much criticism worldwide due to the fact all-male social spaces cultivated by rugby appear to support and sustain hyper-masculine and hyper-normative behaviours, including gender-related violence (Cosslett, 2014; Guinness & Besnier, 2016).

[4]The origins of this oft-cited Rugby adage is unclear. The phrase is supposedly the adopted motto of the British Barbarians Football Club, established in 1890 (Dunning & Sheard, 2005, p. 34). The complete phrase reads "Rugby is a game for barbarians played by gentlemen, football is a game for gentlemen played by barbarians." However, official club history cites its original motto as, 'Rugby Football is a game for gentlemen in all classes, but for no bad sportsman in any class' (Starmer-Smith, 1977, p. vii). Some sources attribute the saying to British writer and poet Oscar Wilde (1854-1900) (David, 2015)

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