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Mechanistic explanations in the cognitive social sciences: Lessons from three case studies

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Abstract

Discussions of the relations between the social sciences and the cognitive sciences have proliferated in recent years. Our article contributes to the philosophical and methodological foundations of the cognitive social sciences by proposing a framework based on contemporary mechanistic approaches to the philosophy of science to analyze the epistemological, ontological and methodological aspects of research programs at the intersection of the social sciences and the cognitive sciences. We apply this framework to three case studies which address the phenomena of social coordination, transactive memory, and ethnicity. We also assess how successful these research programs have been in providing mechanistic explanations for these phenomena, and where more work remains to be done.

Keywords

cognitive social science, ethnicity, mechanistic explanation, social coordination, transactive memory

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Résumé

Au cours des dernières années, les relations entre sciences sociales et sciences cognitives ont fait l'objet de nombreuses discussions. Notre article contribue à l'élaboration des fondations philosophiques et méthodologiques des sciences sociales cognitives en proposant un cadre qui se base sur des approches mécaniques contemporaines de la philosophie des sciences afin d'analyser les aspects épistémologiques, ontologiques et méthodologiques des programmes de recherche qui se trouvent à l'intersection des sciences sociales et des sciences cognitives. Nous utilisons ce cadre pour se pencher sur trois études de cas s'intéressant aux phénomènes de coordination sociale, de mémoire transactive et d'ethnicité. Nous évaluons aussi à quel point ces programmes de recherche ont réussi à fournir des explications mécaniques pour ces phénomènes, et où il est désormais nécessaire de concentrer nos efforts.

Mots-clés

coordination sociale, ethnicité, explications mécaniques, mémoire transactive, sciences sociales cognitives

The social sciences and the cognitive sciences have grown closer together during recent decades. On the one hand, there has been a social turn in the cognitive sciences, as indicated by the emergence of social neuroscience and other experimental research programs at the interface of the cognitive and social sciences (Cacioppo et al., 2012; Lieberman, 2017). On the other hand, many theoretically and empirically oriented social scientists have become more interested in and informed by the cognitive sciences, as indicated by the emergence of new research fields, such as cognitive sociology (Bouvier, 2007; Brekhus & Ignatow, 2019; Cerulo, 2010; DiMaggio, 1997; Lizardo et al., 2020; Shaw, 2015), behavioral economics (Dhami, 2016; Thaler, 2015), and new approaches in cognitive anthropology (Bloch, 2012; D'Andrade, 1995; Hutchins, 1995; Sperber, 1996). We call these research fields that aim to integrate the social sciences with the cognitive sciences *cognitive social sciences* (cf. Turner, 2001; Lizardo, 2014).

Current interdisciplinary exchanges between the cognitive sciences and social sciences raise many philosophical and methodological challenges. Piet Strydom (2007) identifies a number of different positions in cognitive social theory and describes the main lines of disagreement between the proponents of strong and weak cognitivism in how they understand cognition and the relation between the cognitive and social sciences. Gabe Ignatow (2014) regrets that cognitive sociologists have not been clear about their ontological and epistemological commitments, suggesting that the bridge being built between sociology and the cognitive sciences would be enhanced, if cognitive sociologists would take a stance in philosophy of social science debates, such as those pertaining to (critical) realism, naturalism and social constructionism. Stephen Turner (2018) provides a comprehensive discussion of ongoing philosophical and methodological debates that relate to interdisciplinary exchanges between the cognitive sciences and the social sciences. Tuukka Kaidesoja and colleagues (2019) evaluate four recent arguments that have been presented in favor of integrating the cognitive sciences with the social sciences. And Baptiste Brossard and Nicolas Sallée (2020) call for epistemological 'conversion work' between psychology and sociology that would enhance interdisciplinary projects in a way that takes seriously the potential epistemic risks and benefits of these projects.

Our article contributes to previous discussions about the relation between the cognitive sciences and the social sciences by proposing a mechanistic approach based on the philosophy of science in order to analyze the epistemological, ontological and methodological aspects of the cognitive social sciences (Bechtel & Abrahamsen, 2005; Bechtel, 2008; Craver & Darden, 2013; Glennan, 2017; Hedström & Ylikoski, 2010). We will argue that mechanistic philosophy of science provides a suitable framework for evaluating where current cognitive social scientists have been successful in explaining social phenomena, and where more work remains to be done. Moreover, we will apply this framework to three case studies based on research programs in the cognitive social sciences. In our first case study on interpersonal social coordination, we will argue that mechanistic philosophy of science can ground a feasible division of labor between cognitive and social scientists studying the same phenomena by identifying different questions about cognitive and social mechanisms (and the environments in which they operate) to which they answer. In our second case study on the transactive memory of groups, we will argue that mechanistic philosophy of science can be used to challenge pre-reflective ontological distinctions between fixed cognitive and social domains or 'levels of reality', since some cognitive mechanisms transcend the brains and bodies of individuals into the material and social environments that they inhabit. And in our third case study on ethnic phenomena, we will argue that cognitive mechanisms are modulated by the social environments in which they operate, and therefore cognitive science also needs inputs from the social sciences, in addition to the social sciences benefiting from inputs from the cognitive sciences. We will begin by presenting the central ideas of a mechanistic philosophy of science.

Mechanistic philosophy of science and the cognitive social sciences

Mechanistic philosophy of science (MPS) provides a systematic ontological, epistemological and methodological framework for addressing philosophical issues concerning attempts to integrate the social sciences with the cognitive sciences (for comprehensive accounts of MPS, see Bechtel, 2008; Craver & Darden, 2013; Glennan, 2017; Glennan & Illari, 2018). Historically, the mechanistic approach to explanation was proposed as an alternative to the once dominant deductive-nomological account of scientific explanation (Hempel, 1966), and it has since then been applied to a variety of different scientific fields, such as cognitive science (Bechtel, 2008; Craver, 2007), genetics and molecular biology (Craver & Darden, 2013), and the social sciences (Hedström & Ylikoski, 2010). In this section, we introduce the basic ideas of MPS and point out their relevance to the explanatory practices of the cognitive social sciences. We will build upon the following 'minimal' account of mechanisms that has been proposed by Stuart Glennan (2017: 17):

> A mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon. (Glennan, 2017: 17)

Glennan's minimal account of mechanisms is compatible with more specific types of mechanisms that are studied in the cognitive and social sciences as well as with alternative explications of mechanisms by other philosophers of science (e.g. Bechtel & Abrahamsen, 2005; Hedström & Ylikoski, 2010; Machamer et al., 2000; Woodward, 2013).

As the minimal account makes clear, most advocates of MPS subscribe to the view that mechanisms are composed of two basic kinds of constituents: entities and activities. Entities are particular things (in a broad sense) in the world and activities always take place in some entity. The entities that are studied in different sciences are highly diverse, ranging from molecules to brains and complex social systems. Entities may engage in activities either by themselves or in concert with other entities. When the activities of two or more entities influence each other, they interact. In a mechanism that is responsible for some phenomenon, its constituent entities and activities as well as their interactions are organized in a way that allows them to produce, maintain or underlie the phenomenon, meaning that there are specific constitutive and causal relations between these constituent entities and activities. Every mechanism is responsible for some phenomenon, but unlike some other advocates of the mechanistic approach (e.g. Craver & Darden, 2013: 15), Glennan (2017: 24–25) does not require mechanisms to be responsible for only regular or recurrent phenomena. He admits the possibility of 'ephemeral mechanisms' that produce one-off phenomena, such as singular historical events (Glennan, 2017: 27). The notion of ephemeral mechanisms is useful in the social sciences since social scientists who use case study methods are often interested in explaining singular historical events.

MPS regards mechanisms as hierarchical in the sense that lower-level mechanisms operate as parts of higher-level mechanisms (e.g. Craver & Darden, 2013; Glennan, 2017). When scientists investigate a mechanism that is responsible for a specific phenomenon, they commonly assume that there are underlying mechanisms that allow the constituent entities of the mechanism to engage in the activities that they engage in. Conversely, a mechanism identified at a lower level of mechanistic organization is typically embedded in some broader (or higher-level) mechanism that affects its functioning. For example, a mechanism underlying the working memory of a particular person may operate as a part of the social mechanism of collaborative learning in which the person is engaged in a common learning task with her classmates. Social and cognitive scientists often implicitly or explicitly attribute different types of cognitive capacities to people, such as the capacities to act intentionally, to communicate using spoken or written language, and to remember things in the past. As Glennan (2017: 51–52) argues, the capacities of complex entities are mechanism-dependent in the sense that the organized interactions of their parts are responsible for the capacities of the whole entity, which may manifest themselves only in suitable environments. For example, the capacity for speech is dependent on the organized interactions of neural mechanisms and manifested in communicative interactions with other people.

According to MPS, mechanisms are identified on the basis of the phenomena that they contribute to (e.g. Craver & Darden, 2013; Hedström & Ylikoski, 2010; Glennan, 2017). For example, cognitive neuroscientists investigate the neural mechanisms underlying working memory and visual perception (Bechtel, 2008), while social scientists study the social mechanisms of self-fulfilling prophecy and urban segregation (Hedström, 2005). They both use empirically established phenomena to delimit the boundaries of the mechanism under investigation, and to identify the entities and activities that are relevant for the phenomenon in question. When they study highly complex systems, such as biological organisms or social groups, scientists may also get different mechanistic decompositions of the same system when they focus on different phenomena in the system (Glennan, 2017: 37–38). But once they have identified a phenomenon in a system, the boundaries of the mechanism that is responsible for it are determinate and do not depend on the ways the mechanism is represented. An important implication of this is that mechanistic levels are always relative to some phenomenon of interest, meaning that there are no global levels of mechanisms. This implies that cognitive social scientists should be cautious regarding the methodological value of highly abstract mechanism types, such as ‘biological mechanism’, ‘psychological mechanism’ and ‘social mechanism’, since they tend to refer to heterogeneous arrays of mechanisms rather than to fixed ‘ontological levels of reality’.

While mechanisms are always particular and spatiotemporally local, scientists are interested in making generalizations about them and classifying them into kinds. According to MPS, scientists achieve generality by constructing models about classes of particular mechanisms. Mechanistic models ‘describe (in some degree and some respect) the [target] mechanism that is responsible for some phenomenon’ (Glennan, 2017: 66). An important way to achieve generality is by abstracting away from the details of particular mechanisms and idealizing some of their features. For example, many models of social mechanisms not only abstract away from most neural and cognitive mechanisms that underlie the interactions of individual actors but may also include idealized descriptions of the cognitive capacities of actual human beings (cf. Hedström, 2005; Hedström & Ylikoski, 2010). Abstractions omit details regarding the target mechanism while idealizations distort some features of the target mechanism (Craver & Darden, 2013: 33–34, 94; Glennan, 2017: 73–74). There is no general criterion regarding the acceptability of abstractions and idealizations in a mechanistic model – rather, the appropriateness of particular abstractions and idealizations should be decided in a case-by-case manner depending on the epistemic aims of the researcher (Craver & Kaplan, 2018; Glennan, 2017).

In MPS, mechanistic explanations are characterized as representations of mechanisms that underlie, maintain or produce some phenomenon (e.g. Bechtel, 2008; Craver & Darden, 2013; Glennan, 2017). Representations of mechanisms may take many different forms, such as qualitative descriptions, diagrams, equations or computational simulations. We call all of these ‘mechanistic models’. Mechanistic explanations may unify phenomena that were earlier regarded as unconnected by revealing that their underlying mechanisms are similar. Mechanistic explanations may also split phenomena that were earlier regarded as similar by revealing that their underlying mechanisms are different. However, mechanistic explanations do not reduce the phenomena to be explained to some lower level phenomena without remainder. Rather, they help us understand how the phenomena to be explained arise from the organized interactions of its constituent entities and activities in a specific environment. Thus MPS is not a strongly reductionist (or an eliminativist) methodological program, although mechanistic explanations are sometimes characterized as reductive explanations (e.g. Wimsatt, 2007: chapter 11; Bechtel, 2008: chapter 4).

Some critics of MPS have claimed that advocates of this view assume that more detailed mechanistic explanations are always better (e.g. Batterman & Rice, 2014), although the latter have explicitly distanced their views from this idea (e.g. Glennan, 2017; Craver & Kaplan, 2018). Even if it is clear that a mechanistic explanation should describe *some* entities and activities that contribute to the phenomenon to be explained, mechanistic explanations may vary with respect to their completeness, and the epistemic purposes of researchers should be taken into account when assessing the relevance of adding more detail to a mechanism model. Accordingly, in their well-known article on causal mechanisms in the social sciences, Peter Hedström and Petri Ylikoski (2010: 60) conclude that 'only those aspects of cognition that are relevant for the explanatory task at hand should be included in the explanation, and the explanatory task thus determines how rich the psychological assumptions must be'. Cognitive explanations of social phenomena may accordingly involve various degrees of realism and complexity, and more detailed multi-level explanations are not automatically more satisfactory than explanations that focus on a more straightforward or selective subset of causes.

Cognitive scientists commonly understand cognitive (or mental) mechanisms as mechanisms that process information (e.g. Bechtel, 2008: ix; Bermudez, 2010; Milkowski, 2013).[1] The study of information processing (understood in computational terms as requiring an algorithmic analysis of how a given task is performed) was traditionally taken to be relatively autonomous with respect to studying the physical realizers of those information processing tasks (e.g. Marr, 2010 [1982]). On the algorithmic level, information processing was operationalized as symbol manipulation in a syntactically specified physical system (Newell, 1980; Newell & Simon, 1972) or as changes in connection weights within artificial neural networks inspired by actual neural networks (Rumelhart & McClelland, 1986). During recent decades, in what Worth Boone and Gualtiero Piccinini (2016) have dubbed the 'cognitive neuroscience revolution', cognitive scientists have taken important strides towards a multilevel mechanistic framework that provides a non-reductionist physical grounding for cognitive mechanisms. By contrast to the highly idealized nature of traditional symbol manipulation and artificial neural network accounts, which may be at most regarded as abstract and highly idealized representations of actual neural networks, contemporary cognitive scientists understand the human brain as imposing important constraints on the realization and operation of cognitive tasks.

In accordance with the traditional approach to cognitive science, many cognitive social scientists writing today (e.g. Brubaker et al., 2004; D'Andrade, 1995; Strauss & Quinn, 1997; Vaisey, 2009) have sought to explain social phenomena in terms of abstract information-processing structures, such as *cognitive schemas* (Rumelhart, 1980) and *scripts* (Schank & Abelson, 1977). However, against the backdrop of the recent cognitive neuroscience revolution, one may ask to what extent aspiring cognitive social scientists should offer explanations of social phenomena that 'go all the way down' to the neuronal level, and to what extent they may operate on the level of more abstract information-processing structures. In other words, even if one grants that social behavior is not reducible to brain processes – as it arguably is not (Krakauer et al., 2017; Rose & Abi-Rached, 2013) – one might nevertheless consider specifying brain processes to be a *necessary* feature of satisfactory cognitive social science or merely one goal that cognitive social scientists may aspire to satisfy (but need not specify in detail).

While we consider it an important *desideratum* for models of cognitive mechanisms to be grounded in accounts of neural and other physical structures, we believe that it would be problematic to require all cognitive explanations of social phenomena to be couched in neural-physical terms. First, this is because such a requirement would be too demanding, as we often do not know in detail what physical mechanisms realize complex cultural representations (Lizardo et al., 2020). Second, 'full physical grounding' may not always even be necessary, since idealized mechanistic models may serve many explanatory purposes on a greater level of abstraction (Thomson-Jones, 2005). Third, proponents of '4e-cognition' or 'wide cognition' (e.g. Clark, 2008; Milkowski, 2013; Turner, 2018) have argued that some cognitive mechanisms may extend beyond the brains of individuals to the extremities of their bodies and some features of the material environment. They have accordingly argued that cognition is embodied (Clark, 1997; Damasio, 2000; Gallagher, 2005), embedded (Brooks, 1999; Huebner, 2013), materially and socially extended or distributed (Clark & Chalmers, 1998; Hutchins, 1995; Menary, 2010; Sutton et al., 2010) and enactive (De Jaegher & Di Paolo, 2007; Thompson, 2007; Varela et al., 1991), rather than a purely intracranial affair.

According to proponents of wide cognition, cognition is a matter of 'embodied interactions supported and extended by actively built cognitive niches' (Milkowski et al., 2018: 1). We suggest that such dimensions of wide cognition can be accommodated by an expanded mechanistic framework, which is neutral with respect to the fundamental nature of the physical realizers of cognitive processes giving rise to social phenomena, while still requiring that some physical realizers be specified. By using embodied, embedded, extended and enactive approaches to cognition as research heuristics (Milkowski et al., 2018: 4), cognitive social scientists can identify causally relevant cognitive mechanisms without prematurely restricting themselves to a particular view of how cognitive processes are physically implemented.

Drawing on William Bechtel (2009), we propose that mechanistic explanations satisfying the criteria outlined in this section can be formulated by answering the following four questions, which are couched in terms of the intuitive visual metaphors of 'looking at' the phenomenon to be explained, 'looking down' at the parts and activities that give rise to the phenomenon, 'looking around' at the organization and interactions of these parts, and 'looking up' at the environment in which the mechanism operates (for a similar classification, see Craver & Darden, 2013: 163):

1) What is the phenomenon to be explained ('looking at')?
2) What are the relevant entities and their activities ('looking down')?
3) What are the organization and interactions of these entities and activities through which they contribute to the phenomenon ('looking around')?
4) What is the environment in which the mechanism is situated and how does it affect its functioning ('looking up')?

These questions will be used in our case studies as heuristic aids to evaluate which questions various research programs in the cognitive social sciences have been successful in answering, and where more work possibly remains to be done. However, we emphasize that, depending on the epistemic purposes of a researcher, a satisfactory mechanistic explanation may provide only partial answers to some of these questions. Thus we do not treat answering all of these questions in detail as necessary criteria for a satisfactory mechanistic explanation, but as valuable *desiderata* that cognitive social scientists may aspire to satisfy, even if they need not answer them exhaustively. This being said, we also recognize that 'high-level abstract explanations in social sciences, when not properly constrained, or deepened [. . .] remain superficial and explanatorily weak' (Milkowski, 2019: 735). In this respect, Bechtel's four questions provide useful guidelines for cognitive social scientists about how to deepen (Strevens, 2008; Ylikoski & Kuorikoski, 2010) their explanations and make them more robust (Weisberg, 2006; Wimsatt, 2007). Using these four questions as our guides to assessing mechanistic explanations in the cognitive social sciences, we will now turn to our three case studies concerning social coordination, transactive memory and ethnic phenomena.

Case study 1: Social coordination

This section will focus on research on interpersonal social coordination in the fields of developmental psychology (Carpenter & Svetlova, 2016; Rakoczy, 2017), evolutionary anthropology (Tomasello et al., 2005; Tomasello, 2019; Warneken et al., 2006; Warneken & Tomasello, 2009), and cognitive science (Michael et al., 2016; Knoblich et al., 2011; Vesper, Butterfill et al., 2010; Vesper et al., 2016). Through this case study, we will emphasize how the mechanistic framework of explanation can be used to carve out a feasible division of labor between cognitive and social scientists studying the same phenomena. We will first discuss research on social coordination in each of these disciplines, and we will then indicate how the mechanistic framework can aid in integrating their methodological approaches and theoretical outputs with one another.

Research on social coordination in the field of evolutionary anthropology has focused on the phylogenetic differences that there are between the cooperative capacities of humans and their nearest primate relatives, such as chimpanzees and bonobos (Tomasello et al., 2005; Tomasello, 2019; Warneken et al., 2006; Warneken & Tomasello, 2009). Turning their attention away from the Machiavellian intelligence-hypothesis of the 1980s and early 1990s, which viewed human social intelligence as an outgrowth of the urge for manipulation and deceit (Byrne & Whiten, 1988; Whiten & Byrne, 1997), researchers beginning from the late 1990s began to argue for the hypothesis that it was in fact the need for social coordination and cooperation that drove the development of many human social skills and capacities, such as theory of mind (e.g. Dunbar, 2009; Hrdy, 2009; Tomasello, 1999). These social skills and capacities are also reflected in distinctive physiological adaptations, such as large mammalian brain size (Dunbar, 2009) and the unusually large white sclera around the eyes of humans (Kobayashi & Kohshima, 1997). Based on this and further empirical research, Michael Tomasello (2019) argues that the capacity for social coordination was the crucial co-evolutionary adaptation, which made possible the development of unique forms of human culture and civilization (cf. Boyd & Richerson, 2005; Searle, 2010; Tuomela, 2013).

Research on social coordination in the field of developmental psychology has focused on the developmental trajectory of distinctively human forms of social coordination (Carpenter & Svetlova, 2016; Rakoczy, 2017). According to Tomasello (2019: 55), the crucial stage in the development of human forms of social coordination is the 'nine-month revolution', when infants move on from dyadic 'protoconversations' (Trevarthen, 1979) with their caretakers to triadic joint attention (Vygotsky, 1978 [1930]) and social games focused on some shared object of attention in the environment. Later in infancy, the capacity for joint attention develops into the capacity for joint commitment, in which infants come to recognize norms that are associated with engaging in a shared task or attending to an object together (Gräfenhain et al., 2009; Kachel et al., 2018). By contrast to chimpanzees and other primates, human infants seem to have sophisticated skills and a high degree of motivation to engage not only in instrumental shared tasks, but also in non-instrumental social games and joint attention with their caretakers, and later on in infancy, with their peers (Warneken et al., 2006; Warneken & Tomasello, 2009; Tomasello, 2019).

While evolutionary anthropologists and developmental psychologists have made important advances in our understanding of the cognitive capacities for social coordination possessed by human infants and the great apes, they do not address the cognitive and neural mechanisms that underlie these capacities and their exercise in specific environments (see e.g. Esmenio et al., 2020; Frith & Frith, 2012; Gallese & Goldman, 1998; Veissière et al., 2020). In the remainder of this section, we will argue that this gap in our understanding can be partly filled by the cognitive framework for studying social coordination proposed by the cognitive scientists Günther Knoblich and Natalie Sebanz together with the philosopher Stephen Butterfill (Knoblich et al., 2011). They distinguish two different types of social coordination: emergent coordination and planned coordination (Knoblich et al., 2011). According to Knoblich and colleagues (2011: 62), in emergent coordination 'coordinated behavior occurs due to perception–action couplings that make multiple individuals act in similar ways [. . .] independent of any joint plans or common knowledge'. In planned coordination, 'agents' behavior is driven by representations that specify the desired outcomes of joint action and the agent's own part in achieving these outcomes'.

Knoblich and colleagues (2011) discuss four cognitive mechanisms for emergent coordination, which they refer to as entrainment, common object-affordances, perception-action matching, and action simulation. Entrainment refers to the behaviors of two or more individuals becoming synchronized when they are performing the same action or when they receive the same auditory, visual or haptic information (Knoblich et al., 2011: 66), as when two individuals in adjacent rocking chairs involuntarily adjust their rhythms to one another (Richardson et al., 2007). Common object affordances refers to objects that can be manipulated by two or more individuals in ways in which they cannot be manipulated by one individual acting alone, such as a see-saw or a two-handled saw (cf. Gibson, 1977). Perception-action matching refers to mechanisms that induce an individual to perform similar actions as she has observed another individual performing, either by way of the mirror neuron system in the lateral intraparietal area and the ventral intraparietal area of the human brain (Gallese & Goldman, 1998; Rizzolatti & Sinigaglia, 2010) or via ideomotor mechanisms of action control (Hommel et al., 2001; Prinz, 1997). Action simulation refers to an individual using her own action control system to predict what the other agent will do next, thereby facilitating coordination (Goldman, 2008; Knoblich et al., 2011: 71–72).

While emergent coordination is explained primarily by sub-intentional mechanisms of action control, planned coordination is explained by reference to explicit mental representations that are accessible to intentional awareness. Different types and degrees of planned coordination may be distinguished on the basis of the extent to which they involve explicit representations of a common goal, other individuals in a joint action, and/or the division of tasks between the participants (Knoblich et al., 2011; Vesper et al., 2010). Minimal forms of planned coordination may involve only partial representations of some of these features, while cognitively sophisticated forms of planned coordination involve detailed representations of all of them (Vesper et al., 2010). Moreover, some of these aspects of planned coordination may be left open to be filled in by step-by-step joint deliberation as the activity progresses (Bratman, 2014), or by synchronic forms of emergent coordination that operate at the moment the individuals are acting together. Finally, planned coordination may involve deliberate attempts to facilitate coordination by means of coordination smoothers, such as exaggerated hand movements or the adoption of a particular, suggestive gesture (Vesper et al., 2010; 2016).

We may use the preceding discussion to outline a tentative division of labor between cognitive and social scientists studying social coordination based on Bechtel's four desiderata for mechanistic explanation. Developmental social psychologists and evolutionary anthropologists study what cognitive capacities and motivations set apart human infants from the great apes, and the developmental stages through which these capacities and motivations emerge in human ontogeny. This may be understood as an answer to Bechtel's first question concerning the phenomenon that we are looking at (e.g. distinguishing social games from the types of instrumental coordination tasks that chimpanzees are more adept at solving (Warneken et al., 2006)), and his fourth question concerning the ways in which they operate in particular environments (e.g. whether chimpanzees coordinate in a different manner with human partners in the laboratory than with their conspecifics in the wild (see Tomasello, 2011)). By contrast, cognitive scientists address Bechtel's second and third questions by attempting to identify what cognitive mechanisms (e.g. common object affordances, entrainment, and action simulation) make the operation of these species-typical capacities and motivations for social coordination possible. In addition, social scientists may also address further questions about the outcomes of interpersonal social coordination, e.g. by studying complex social networks that are formed when people coordinate their interactions (Borgatti et al., 2009; Watts, 2004).

While the focus of this section has been on small-scale forms of interpersonal coordination, we may also extend the schematic division of labor that has been outlined in this section to more large-scale forms of social coordination. Consider a prototypical phenomenon studied by social scientists, political mobilization (see McAdam et al., 2001; Orum & Dale, 2009; Tilly, 2001; Tilly & Tarrow, 2007). Arguably, social mobilization may involve both emergent and planned forms of coordination: for example, it may involve collective claim making (Tilly & Tarrow, 2007: 3–25), framing a political issue (Benford & Snow, 2000), and brokerage and coalition formation between groups (Tilly, 2001: 24–25), but it may also involve the kinds of emergent synchrony and excitement, which emerge during a political demonstration in the company of like-minded peers, energizing the participants towards new forms of cooperation in the pursuit of their common political agenda.

As has been pointed out by Christian Borch (2020), such forms of emergent coordination have been an enduring interest of social scientists since the dawn of the social sciences, from the 'mob psychology' of Gustave Le Bon (2002 [1895]) and Gabriel Tarde (1962 [1890]) to Émile Durkheim's (1965 [1912]) work on 'collective effervescence' and its recent resuscitation in Randall Collins's (2004) studies of 'interaction ritual chains'. What the cognitive mechanisms identified by Knoblich and colleagues (2011) offer is to identify in more detail what cognitive mechanisms (e.g. entrainment and perception-action matching) may bring about and sustain such forms of emergent coordination. Similarly, while the forms of planned coordination that are involved in political participation are also addressed by sociological methods (e.g. by means of interviews (Pugh, 2013), surveys (Vaisey, 2009) and ethnography (Jerolmack & Khan, 2014)), Knoblich and colleagues' (2011) account of the cognitive mechanisms underlying planned coordination provides a more detailed account of how the relevant representations are internally or externally encoded, stored, and accessed in the pursuit of relevant action goals. Of course, cognitive scientists do not aim to describe the detailed content of such representations (that is a task for social scientists), but their research may identify relevant constraints and affordances in how this information is processed, which may also influence the outcomes of complex social processes. For example, Charles Tilly and Sidney Tarrow (2007: 14) study a number of episodes of 'contentious politics' ranging from the post-soviet disintegration of Yugoslavian state to the Mexican Zapatistas in order to understand how 'similar mechanisms and processes produce distinctive political trajectories and outcomes depending on their combinations and on the social bases and political contexts in which they operate'.

To draw together the results of this section, we have argued that cognitive scientists and social scientists answer different questions about mechanisms that bring about and sustain social coordination in different environments and over time. Thus they are in a position to make mutually interlocking, yet irreducible contributions to a unified mechanistic framework for explaining social coordination, even if they may also reach results that undermine or challenge assumptions that are deeply ingrained in the other group of disciplines. This result was first defended by a detailed discussion of research on the nature and mechanisms of small-scale interpersonal coordination in the fields of cognitive science, developmental psychology, and evolutionary anthropology. Then it was generalized by reference to a prototypical case of large-scale social coordination studied in the social sciences, political mobilization. Thus we conclude that the schematic division of labor that we have articulated in this section holds both in the case of small-scale and large-scale forms of social coordination, when it is relevant for social scientists to identify cognitive mechanisms underlying the phenomena that they study in order to make their explanations deeper or more robust.

Case study 2: Transactive memory

The notion of a transactive memory system (TMS) originated in the work of social psychologist Daniel Wegner and his collaborators in the 1980s. Since then TMSs have been studied in cognitive, organizational and social psychology as well as in communication studies, information science and management (Lewis & Herndon, 2011; Ren & Argote, 2011; Peltokorpi, 2008; Peltokorpi & Hood, 2018). Although research on TMSs has dispersed among many disciplines, it forms a unitary research program in the sense that researchers in different fields use the same conceptual framework to communicate with each other. This section begins with a discussion of the basic features of TMSs, as described by Wegner and his collaborators. Then we provide a mechanistic interpretation of TMSs and suggest how the mechanistic approach could advance further research on TMSs and other social memory phenomena. This case study offers an example of cognitive social scientific research where memory phenomena are explained in terms of socially extended cognitive mechanisms that transcend the brains and bodies of individuals.

According to Wegner and colleagues (1985: 256):

> Transactive memory can be defined in terms of two components: (1) an organized store of knowledge that is contained entirely in the individual memory systems of the group members, and (2) a set of knowledge-relevant transactive processes that occur among group members.

They attribute TMSs to groups insofar as these groups perform functionally equivalent roles in group-level cognitive processes as individual memories perform in the cognitive processes of individuals (Wegner et al., 1985: 256). In their experiments, Wegner and colleagues (1985) compared the problem-solving strategies that 'close' couples and 'distant' couples used in answering simple factual and opinion questions. They found that, unlike distant couples, close couples solved these problems by using integrative strategies, such as interactive cuing in memory retrieval, that support the hypothesis that they develop and utilize a TMS. Wegner (1986) makes it clear that the intended scope of TMS theory also encompasses groups that have more than two members. Subsequent research on TMSs has accordingly addressed small interaction groups, work teams and even organizations in addition to intimate couples (e.g. Ren & Argote, 2011; Peltokorpi, 2008).

TMS theory aims to explain how a transactive memory system develops, is maintained over time, and modulates the cognitive functioning of the group. What is crucial for the development of a TMS is that the group members have at least partially different domains of expertise that are relevant to the group's cognitive tasks and that the group members have learned about each other's domains of expertise (Wegner, 1986: 190–191). If these two conditions are met, then each group member is able to utilize the other group members' domain specific information in group-related cognitive tasks and to transcend the limitations of their own internal memories. Hence, Wegner and colleagues (1985: 256; see also Wegner, 1986: 191) argue that the development of a TMS involves forming 'a knowledge-acquiring, knowledge-holding, and knowledge-using system that is greater than the sum of its individual member systems'. Although it highlights the importance of 'emergent properties' of this kind, TMS theory does not claim that all groups have TMS nor does it claim that groups always cognitively outperform individuals in memory tasks.

The component entities of a TMS are the memory systems of interdependent individuals who encode, store and retrieve information about their domains of expertise and information about the division of cognitive labor (i.e. who knows what) within the group (Wegner, 1986: 186–187). Wegner (1986: 187–189) notes that, in addition to their brain-based memories, individual group members may also utilize material artifacts, such as notebooks, archives and data files, as their memory stores. In contrast to their internally stored information, individuals have to know the location of a particular piece of information that they have stored in their external storage media in order to be able retrieve it. Moreover, Wegner (1986: 189) argues that other members' internal and external memory storages can be understood as the focal member's external memory storages as long as she knows their domains of expertise and is able to communicate with them.

The main interactions between the component entities of a TMS (also called 'process components') are transactive encoding, transactive storing and transactive retrieving of information (Wegner et al., 1985: 258–263; also Wegner, 1986). The names of these interactive processes come from an analogy between the functioning of individuals' memories and the functioning of transactive memory systems. In transactive encoding, group members 'discuss incoming information, determining where and in what form it is to be stored in the group' (Wegner, 1986: 190). Once the coding issues are settled, each group member is responsible for storing the information that belongs to her domain of expertise in her individual memory system, which may have both internal and external components. Finally, transactive retrieval is triggered when a particular group member needs information that is stored by some other group member. Transactive retrieval thus 'requires determining the location of information and sometimes entails the combination or interplay of items coming from multiple locations' (Wegner, 1986: 190). In order to succeed in this process, all group members have to know what the other members' domains of expertise are and how they can be reached. They also have to be willing to share their information with each other. We call these three interacting processes transactive mechanisms since they underlie the operations of a TMS.

The dynamic organization of transactive mechanisms can be analyzed in terms of communicative complexity, task complexity, spatial organization, temporal organization and causal complexity (Theiner, 2013: 75–82; Lewis & Herndon, 2011). The cognitive mechanisms underlying the TMS of a group may thus be implemented in quite different ways depending on the type of group that we are studying (e.g. a romantic couple or work teams in a software company). While there is empirical evidence that a TMS enhances the group performance of small task-oriented groups in many joint memory tasks (Peltokorpi, 2008; Ren & Argote, 2011), in some cases groups with TMS may perform worse than the group members would have performed in isolation due to the phenomenon of collaborative inhibition (Theiner, 2013). Contextual factors modulating the operations of a transactive memory system may include stress, environmental turbulence, trust and broader social networks (Theiner, 2013: 82–83; Lewis & Herndon, 2011).

To accommodate the phenomenon of transactive memory within a broader social psychological context, Amanda Barnier and her collaborators (Barnier et al., 2008) have developed a multidimensional conceptual framework drawing on the distributed cognition approach, which includes research on transactive memory systems (in addition to collaborative recall and social contagion of memories) as a special case (see also Sutton et al., 2010). The distributed cognition approach addresses ways in which people coordinate their communicative interactions by skillfully utilizing various external resources as parts of their cognitive processes (e.g. Hutchins, 1995). Barnier and colleagues (2008: 37–38) propose a useful distinction between three theses pertaining to the degree of social distribution of memory:

> The Triggering Thesis: remembering is a cognitive process that takes place inside individuals, although it can be initiated, at either the encoding or the retrieval phase, by social phenomena.
>
> The Social Manifestation Thesis: remembering is a cognitive process that can only be manifested or realized when the individuals engaged in that process form part of a social group of a certain kind.
>
> The Group Mind Thesis: remembering is a cognitive process that groups themselves, rather than the individuals that compose those groups, engage in.

They use this classification to identify the presuppositions of different cognitive and social scientific perspectives on the social aspects of memory. While cognitive psychological research on social remembering has mostly assumed the triggering thesis, Barnier and colleagues (2008: 38–39) argue that transactive memory systems are best described in terms of the social manifestation thesis. The group mind thesis, however, is implied by some social scientific discussions of collective memory (e.g. Olick, 1999). This thesis is not explored by Barnier and colleagues (2008: 38) in detail, although they argue that it should be regarded as an empirical question whether the group mind thesis can be applied to particular types of collective remembering. Hence, they suggest that different types of social distribution may be manifested by different types of memory phenomena. Barnier and colleagues (2008: 43) also discuss the costs and benefits of distributing memories socially, the ways in which social context influences remembering, the fate of memories during and after communicative interactions, and the social functions of group memory. They operationalize these dimensions in terms of a group of variables, which are applied in their experimental studies of the social contagion of autobiographical memories, collaborative flashbulb memories, and 20-year reunion participants' memories of high school (Barnier et al., 2008: 44–48). When combined with the mechanistic theory of explanation, their multidimensional framework provides useful tools for overcoming the conceptual and methodological gap that still exists between cognitive scientific and social scientific approaches to memory phenomena.

In summary, we have argued in this section that TMS theory provides a promising conceptual framework for developing mechanistic explanations for emergent memory phenomena, but current research on TMSs exhibits certain limitations. The idea of a transactive memory system is often employed by experimenters who are more interested in establishing experimental effects (e.g. whether the TMS enhances the cognitive functioning of the group) than describing the cognitive mechanisms through which these effects are brought about in different types of groups. However, as we mentioned above, research on TMSs has challenged brain-bound accounts of memory by suggesting that cognitive mechanisms underlying emergent memory phenomena in groups are manifested in social interactions between group members that may involve material artifacts as external memory storages. This links the research program on TMSs to extended and distributed cognition approaches in the cognitive sciences (e.g. Hutchins, 1995; Clark, 1997, 2008; Milkowski et al., 2018). By drawing on Barnier and colleagues' (2008) work, we pointed out that there are also many other social memory phenomena that could be addressed by combining the distributed cognition approach and mechanistic philosophy of science. This broader perspective may allow cognitive social scientists to address many of those social memory phenomena that social scientists have discussed under the rubric of collective memory.

Case study 3: Ethnicity

The sociologist Rogers Brubaker and his research companions (Brubaker et al., 2004) have outlined a cognitive approach to ethnicity, nationhood and race (which we will refer to broadly as 'ethnic phenomena'). Their approach can be analyzed with the aid of mechanistic philosophy of science since the idea of explaining social phenomena with mechanisms is implied in their work. For example, Rogers Brubaker and David Laitin (1998: 447) suggest that it would be beneficial 'to identify, analyze, and explain the heterogeneous processes and mechanisms' that produce the group of phenomena which are classified as ethnic violence. Brubaker and colleagues (2004: 37) propose that it 'would help specify – rather than simply presuppose – the cognitive mechanisms and processes involved in the working of ethnicity, and would strengthen the micro-foundations of macroanalytical work in the field'. Given that ethnicity is a complex macrosocial phenomenon, we will focus in this section on the ways in which cognitive mechanisms that underlie ethnicity interact with the broader cultural environment that they are embedded in, and how social scientific research methods may complement the research methods of the cognitive sciences in studying these interactions.

Brubaker and colleagues (2004: 31–32) challenge traditional approaches to ethnicity, nationhood and race that view them as substantial entities with clear boundaries, and may attribute to them interests and agency (see Delanty & Kumar, 2006; Solomon & Goldberg, 2002). Rather, they treat them as different ways of seeing the world, which are based on universal cognitive mechanisms, such as categorizing the world into 'us' and 'them' (Brubaker et al., 2004: 45). Although one might be worried that the cognitive approach ends up simply re-describing the *explanandum* in a manner that fits with the abstract cognitive mechanisms that are assumed to explain all of these phenomena, we think that their approach is quite promising. However, in order to address the types of phenomena that social scientists are interested in explaining, we will argue that one must pay attention not only to the cognitive mechanisms that serve as the internal vehicles of ethnic representation, but also to the culture-specific contents that these vehicles carry, as well as public representations that are embedded in the cultural environment. Otherwise the cognitive approach to ethnicity would not be in a position to address the types of heterogeneous manifestations of ethnic phenomena, which according to many researchers, are the proper subject matter of the social sciences (see Delanty & Kumar, 2006; Solomon & Goldberg, 2002; Wimmer, 2008).

Brubaker and colleagues (2004: 37–44) seek to explain ethnic phenomena in terms of the following three cognitive mechanisms, which are described in abstract information-processing terms: stereotypes, social categorization and schemas. Stereotypes are understood as 'cognitive structures that contain knowledge, beliefs, and expectations about social groups' (Brubaker et al., 2004: 39). They involve cognitive biases since they lead people 'to evaluate evidence in selective ways that tend to confirm prior expectations' (ibid: 49). Following Paul DiMaggio's (1997: 269) definition, schemas are characterized as 'both representations of knowledge and information-processing mechanisms', which 'guide perception and recall, interpret experience, generate inferences and expectations, and organize action' (Brubaker et al., 2004: 41). For example, in the process that Brubaker and colleagues (2004: 44) describe as *ethnicization*, 'ethnic schemas become hyper-accessible and in effect crowd out other interpretive schemas'. Social categorization in turn is described as a cognitive process that maintains subjectively experienced boundaries between social groups. To illustrate this process, Brubaker and colleagues (2004: 40–41) discuss Henri Tajfel's (Tajfel, 1970; Tajfel & Turner, 1986) social identity theory, according to which people tend to favor members of their own group, even if the group was formed arbitrarily. Tajfel's empirical studies have produced evidence that people tend to overestimate the similarities between objects that are considered to belong to the same category and the differences between objects that are considered to belong to different categories.

While schemas, stereotypes and social categorization are taken by Brubaker and colleagues (2004) to be involved in all ethnic phenomena, their content and mode of operation vary culturally. For example, with respect to the content of stereotypes, they range from the harmless, such as the idea that a member of some nation is always happy, to the pejorative, such as the idea that a member of some other nation is always dishonest (Brubaker et al., 2004: 38–40). With respect to the mode of operation, ethnic schemas and stereotypes are 'activated by particular, culturally specific cues' (Brubaker et al., 2004: 40; cf. Brubaker et al., 2004: 42). For example, in their case study of Cluj, a Romanian town with a significant Hungarian minority (Hungarians and Romanians share a history of ethnic tension), Brubaker and colleagues (2006) found that public discourse was filled with ethnic rhetoric, suggesting that the probability of ethnic conflict was high. However, they found that ethnic tension was surprisingly scarce in everyday life, although there were episodes when it became highly salient. By collecting data with interviews, participant observation and group discussions, they were able to identify cues in various situations that turned a unique person to a representative of an ethnic group. Their approach illustrates how cognitive accounts of social phenomena may be supplemented by traditional social scientific research methods, such as ethnographic and survey methods, when we seek to understand relevant features of the cultural environment in which cognitive mechanisms underlying social phenomena operate.

There are also some features of the cultural environment that Brubaker and colleagues (2004) pay quite limited attention to. For example, they do not discuss in detail how ethnic schemas or stereotypes spread in a population and become shared by a large group of people, or why they remain stable or change over time. Some answers to these questions might be provided by additional explanatory resources, such as Dan Sperber's (1996) epidemiology of representations or Michael Tomasello's (2019) ideas about cultural transmission. We believe that Brubaker's cognitive approach to ethnicity could be enriched by integrating deeper these approaches. For example, Sperber's (1996: chapter 2) distinctions between mental and public representations and between a single user and cultural representations could turn out to be useful in studying how cognitive schemas and stereotypes spread in different populations (see also Brubaker et al., 2004: 46). By extension, Brubaker's cognitive approach to ethnicity is accordingly conducive to methodological pluralism, where social scientific research methods are combined with heterogeneous approaches from the cognitive sciences and other fields such as 'cultural epidemiology' to make sense of how cognitive mechanisms interact with the broader cultural environment in which they operate.

Another way in which Brubaker's cognitive approach to ethnicity could be enriched is by more explicit consideration of social mechanisms that influence ways in which particular ethnic boundaries are manifested. For example, Andreas Wimmer (2008: 972) proposes a multilevel process theory, which aims to explain 'different degrees of political salience of ethnic boundaries, of social closure and exclusion along ethnic lines, of cultural differentiation between groups, and of stability over time'. Wimmer (2008) combines heterogeneous elements, such as, the actors' strategies of boundary making, the constraining role of social fields and different stabilizing and de-stabilizing mechanisms, to create a model that describes how and when ethnic boundaries emerge, stabilize and change. While Wimmer (2008: 975) also discusses individual-level conceptual categories and scripts that guide ethnic cognition, his focus is on the social mechanisms that influence how ethnic boundaries are manifested in diverse environments and over time. In this sense, Brubaker's and Wimmer's approaches complement one another: Brubaker's cognitive approach strengthens and clarifies the microfoundations of Wimmer's multilevel account and Wimmer's multilevel account allows us to understand causes for historical and cultural variation in ethnic boundaries.

Overall, we think that the cognitive approach to ethnicity proposed by Brubaker and his research companions provides an interesting discussion of some cognitive mechanisms underlying ethnic phenomena and an insightful criticism of traditional approaches to ethnicity, nationhood and race. Given its focus on macrosocial phenomena, it also allows us to identify challenges that are associated with identifying ways in which cognitive mechanisms interact with the broader cultural environment in which they operate, and the ways in which cognitive and social scientific research methods complement one another. As a critical point, we think that Brubaker and his companions describe the cognitive mechanisms of social categorization, schemas, and stereotypes in a somewhat ambiguous manner that attributes to them numerous functions, and their interrelations and neural underpinnings are not adequately discussed (see e.g. Amodio, 2014). For example, one might ask whether an ethnic stereotype forms a component of an ethnic schema or whether these are independent mechanisms (cf. Sun, 2012: 12–14). In addition, recent discussions in cognitive sociology have distinguished between different types of schemas and considered their relation to 'frames', understood as 'situational assemblages of material objects (i.e., public culture) that activate networks of schemas (i.e., personal culture) in receivers' (e.g. Wood et al., 2018: 250). Thus Brubaker's cognitive approach to ethnicity could also be improved by paying more detailed attention to the nature of the cognitive mechanisms that underlie ethnicity, as well as their neural and physical underpinnings.

Conclusion

This article has proposed to think of mechanistic philosophy of science (MPS) as a systematic meta-theoretical framework for analyzing the epistemological, ontological and methodological aspects of the cognitive social sciences. We have presented the central ideas of mechanistic philosophy of science, and discussed different aspects of the cognitive social sciences through three case studies, which concerned interpersonal social coordination, transactive memory systems, and ethnicity. In this section, we briefly summarize the central conclusions of each of our case studies.

Our first case study concerned research on the fundamental nature and on the mechanisms of human social coordination in the fields of developmental social psychology, evolutionary anthropology and cognitive science. Our central conclusion from this case study was that mechanistic philosophy of science can ground a feasible division of labor between cognitive and social scientists studying the same phenomena by identifying different questions about cognitive and social mechanisms (and the environments in which they operate) to which they can answer.

Our second case study concerned research on transactive memory systems in the fields of social psychology, organization studies and cognitive science. Our central conclusion from this case study was that some emergent memory phenomena in small groups are best explained in terms of socially extended transactive mechanisms, which transcend the brains and bodies of individuals into the social environments, which they inhabit. This case study enabled us to challenge pre-reflective distinctions between fixed cognitive and social domains, or 'levels of reality'.

Our third case study concerned cognitively inspired research on ethnic phenomena in sociology. Our central conclusion here was that cognitive mechanisms contribute to ethnic phenomena, but are also modulated by the broader cultural environment in which they operate. Therefore, cognitive scientific approaches often need to be supplemented by social scientific approaches, such as interviews, ethnographic methods and survey research, when studying the environments in which cognitive mechanisms operate in everyday life.

Based on our case studies, we conclude that mechanistic philosophy of science can help us understand the division of labor between the cognitive sciences and the social sciences, the ontological basis of cognitive mechanisms, and the ways in which cognitive mechanisms interact with the broader cultural environment in which they operate. We have also shown that mechanistic philosophy of science can accommodate social phenomena of various scales, from small-scale interpersonal phenomena to large-scale cultural phenomena, and that satisfactory mechanistic explanations may involve varying degrees of detail about cognitive mechanisms and their physical underpinnings. Finally, we have shown where some prominent contemporary research programs in the cognitive social sciences have been successful in identifying cognitive mechanisms for social phenomena, and where more work remains to be done.

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Note

1. For example, Marcin Milkowski (2013: 24) proposes that ‘the notions of computation and information processing be used interchangeably’.

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