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On the Connection Between Agent-Based Simulation and Methodological Individualism

Abstract: This paper investigates the relationship between methodological individualism (MI) and Agent-Based Simulation (ABS). We use a thesis defended by Caterina Marchionni and Petri Ylikoski (2013) as the starting point of our approach. According to this thesis, since MI is often considered to be a reductionist orientation, it is confusing and meaningless to assume that ABS, which is a non-reductionist and emergentist explanatory model, is committed to MI. We criticize this view and focus on the problem of the proper definition of MI. We explain that MI is compatible with the ABS strategy because reductionism is only the most simplistic variant of MI and argue that ABS explanations must be regarded as explanations in terms of non-reductionist MI.

Keywords: Agent-Based Simulation, Methodological Individualism, Emergence, Reductionism, Downward/Upward causation

1. Introduction

This paper investigates the relationship between methodological individualism (MI) and Agent-Based Simulation (ABS). To achieve this goal, we refer to a stimulating article entitled “Generative Explanation and Individualism in Agent-Based Simulation” by Caterina Marchionni and Petri Ylikoski (2013). According to this article, it is “misleading” and confusing to regard ABS models as implementations of MI (2013, p.2). This is because, while ABS is a systemic and emergentist approach, MI, as highlighted by most contemporary social philosophers, is committed to reductionism. Marchionni and Ylikoski agree with the dominant interpretation of MI in terms of reductionism, but they do not clarify their reasons for doing so. They consider it irrelevant to clarify this point because, for their argument, what matters is only what is commonly understood as the content of MI. They suggest breaking down the relationship between MI and ABS because of practical and utilitarian reasons.

The core concern of our paper is not Marchionni and Ylikoski's thesis, but the legitimacy of the dominant interpretation of MI and its utility to assess the connection between MI and ABS. We use Marchionni and Ylikoski's article as the starting point of our analysis especially because it carefully explains why the dominant interpretation of MI is incompatible with the ABS strategy. We agree with Marchionni and Ylikoski about this incompatibility, but we do not accept their conclusion, which advocates breaking down the relationship between MI and ABS. In our opinion, to avoid confusion regarding the ABS methodology, the problem of the relationship between MI and ABS cannot be analyzed by assuming the dominant interpretation of MI to be the only criterion that must be considered. We contend that the dominant definition of MI is misleading and philologically incorrect. As a consequence, we provide an alternative and more charitable interpretation of MI, which seems to us to be historically more accurate than the dominant one, and assess the compatibility between our interpretation of MI and the ABS strategy. Specifically, we explain that MI is compatible with the ABS strategy because reductionism is only the most simplistic variant of MI and argue that ABS explanations must be regarded as explanations in terms of non-reductionist MI.

The rest of the paper is organized as follows. Section 2 provides a brief review of Marchionni and Ylikoski (2013), upon which our extended discussions are based. Section 3 then reviews two variants of MI, specifically, the non-reductionist variant of MI that, we think, is largely ignored in Marchionni and Ylikoski (2013). Then, grounded on the non-reductionist variant of MI, in Section 4 we reexamine the appropriateness of the treatment of MI by two criticisms, one that interprets MI in terms of semantic reductionism and one that interprets MI in terms of idealist reductionism. Section 5 extends our discussion from methodological individualism to ontological individualism, and their contrasting position to holism (ontological individualism, which is a metaphysical stance that is also referred to as nominalism, is adopted by many, although not by all, supporters of the non-reductionist MI). This enriched framework is further used to shed light on the connection between MI and ABS. In light of the nominalist standpoint that is accepted by many non-reductionist methodological individualists, Section 6 concretely addresses the use of non-individual agents in ABS. Section 7 uses the Micro-Macro links or Micro-Macro problem to highlight the key features commonly shared by MI and ABS, and is followed by our concluding remarks in Section 8.

2. On Marchionni and Ylikoski's Thesis

ABS methodology is the “computational study” of social processes “as open-ended dynamic systems of interacting agents” (Tesfatsion, 2017, p. 384). This approach has gained increasing interest during the last few decades.

As stressed by Marchionni and Ylikoski (Marchionni and Ylikoski, 2013, p. 2), ABS methodology represents a bottom-up research strategy centered on the ideas of “generation” and “mechanism” (Ibid, p. 4). “Generation” means the emergence of systemic macro-properties from agents’ micro-properties (Ibid, p. 4). “Mechanism” means “the systematic variation of the simulation’s assumptions” (Ibid, p. 4) that allows understanding of which “assumptions matter for the model results” (Ibid, p. 5), i.e., “the mechanism implemented in the simulation” (Ibid, p. 5).

Following Marchionni and Ylikoski (Ibid, p. 8), it can be said that ABS methodology allows the simulator to understand the micro-macro causal mechanisms that produce social phenomena as well as the micro-macro causal circularity that is a typical feature of these phenomena. In ABS methodology this circular causality is also known as downward and upward causation (see, for example, Squazzoni, 2009 and Trajkovski and Collins, 2009). Marchionni and Ylikoski stress that ABS assumes that agents are immersed in a structure of interactions that affects their behavior and limits their freedom. As correctly argued by Marchionni and Ylikoski (Marchionni and Ylikoski, 2013, pp. 8-9), the ABS bottom-up explanation presupposes assumptions about agents as well as systemic and non-reductionist assumptions (e.g., structural constraints that produce social conditioning).

For Marchionni and Ylikoski, the view that ABS is an implementation of MI, which has been supported by many authors (e.g., Bulle and Phan, 2017; Manzo, 2014; Macy and Flache, 2009; Neumann, 2008; Sawyer, 2004, p. 263; 2003, p. 340; and Epstein and Axtell, 1996, pp. 16-17), must be rejected. Marchionni and Ylikoski regard this view as highly problematic and confusing because of the dominant interpretation of MI in terms of reductionism in philosophy. According to this interpretation, MI is incompatible with any non-reductionist micro-macro explanatory approach that assumes that structural constraints affect the autonomy and freedom of the individual. This dominant interpretation argues that MI denies: (i) the existence of non-individual or systemic properties; and (ii) the influence of irreducible structural factors on individuals (see Kincaid, 1986;

Udehn, 2001). Marchionni and Ylikoski regard the interpretation of MI in terms of reductionism as correct, but they do not clarify why they think so. They consider it irrelevant to clarify this point because, for their argument, what matters is only what is commonly understood as the content of MI. Their point is that, since MI is usually regarded as a reductionist approach, it is confusing and meaningless to assume that ABS, which is a non-reductionist explanatory strategy, is committed to MI. In their opinion, “the ideas of generation and mechanism are sufficient to define the bottom-up research strategy” of ABS (Marchionni and Ylikoski, 2013, p. 2).

Marchionni and Ylikoski (*Ibid*, p. 10) point out that there are two aspects to note about the reductionist interpretation of MI:

First, [MI] is a thesis about explanation, not about ontology. Therefore, arguments about the existence of social wholes, structures, and such entities vis-à-vis individuals do not directly bear on arguments about explanation of social phenomena. Second, [MI] qualifies as a strong version of methodological individualism in that it holds that explanation of social phenomena should appeal only to individuals, their properties, and interactions. The corollary of such a view is that non-individual properties are denied non-derivative explanatory status.

Marchionni and Ylikoski (*Ibid*, p. 10) recognize that some advocates of MI endorse “weaker versions” of MI, according to which non-individual properties have a causal power and limit individual autonomy. Marchionni and Ylikoski do not develop and clarify this point. They stress several times that they do not want to get entangled in debates about the proper definition of MI and that the only thing that matters for their argument is the content of MI, as understood by the dominant interpretation of that doctrine: “the debate over the proper definition of methodological individualism is a distraction from the real methodological issues” (*Ibid*, p. 9). However, somewhat contradictorily, they are wary of the non-reductionist variants of MI. In their opinion, it “is legitimate to ask...in what sense these more liberal positions are individualistic” (*Ibid*, p. 10). Although Marchionni and Ylikoski’s article has the merit of explaining in detail the reasons why the dominant interpretation of MI is incompatible with the ABS strategy, we disagree with the central thesis supported by their work. In our opinion, within the frame of philosophical analysis, the problem of the compatibility between MI and ABS cannot be satisfactorily analyzed without consideration of the debates on the proper definition of MI, i.e., without assuming that the substantial aspects of this problem are relevant. Breaking down the connection between MI and ABS to avoid confusion because many authors interpret MI in terms of reductionism, while interpreting ABS in terms of non-reductionism, contributes neither to

clarifying the nature of the ABS strategy from a historical and theoretical perspective, nor to avoiding the misunderstanding of it. If, as admitted by Marchionni and Ylikoski, the interpretation of MI in terms of reductionism can be mistaken, then breaking down the relationship between MI and ABS without assessing the value of this interpretation can mean adding even more confusion and mistakes to the literature on ABS.

3. Reductionism, Non-Reductionist MI and ABS

Our goal is to use Marchionni and Ylikoski's views on the relationship between MI and ABS as the starting point to develop our own analysis of this relationship. In our opinion, from a correct historical perspective, the central thesis of MI is not reductionism, but the idea that the ultimate causes of intended and unintended social phenomena are actions of self-determined individuals (see Bulle, 2018).

Following authors such as Karl Popper (1902-1994) and Max Weber (1864-1920), it is possible to argue that the origins of MI "must be sought in the development of scientific history, which implied emancipation from a religious conception of social phenomena" (Di Iorio, 2015, p. 83). Thucydides, the originator of scientific history, put an end to what Popper (1945a, pp. 268-352) called the "theistic" interpretation of history: the idea that there are divine powers behind the scenes. Thucydides explained, for the first time, social phenomena as being solely the intended or unintended product of human actions. His approach paved the way for the development, many centuries later – that is, starting from the Enlightenment – of individualistic theories of the sociological and economic foundations of the social order (see Di Iorio, 2015; Di Nuoscio, 2018). Consider, for example, Adam Smith's "invisible hand", which is a paradigmatic example of explanation in terms of MI. Starting from the Enlightenment, social order was not regarded anymore as the result of divine will, but as a man-made outcome. As stressed by Popper, the development of the anti-individualist approach referred to as methodological holism in the 19th century – an approach originating in the works of Georg Wilhelm Friedrich Hegel (1770-1831), Auguste Comte (1798-1857) and Karl Marx (1818-1883)¹ – can be

¹ Note that, as stressed by Elster (1985) and others, some aspects of Marx's work are compatible with MI. However, others are not. Marx is usually regarded as one of the originators of methodological holism because of his deterministic theory of history (historical materialism) and his ontological and methodological assumptions about the deterministic relationship between the economic base and superstructure, namely, his theory of false

considered to be in a sense a return to the ancient theistic interpretation of history. This is because, like the old religious conceptions of history, holism is centered on the idea that the ultimate causes of social phenomena are not individuals, but supra-individual forces. In other words, holism locates the causes of social phenomena outside the individual, i.e., in supra-individual social entities such as the 'economic structure', the 'culture' or the 'society' and their laws of functioning and evolution (Watkins, 1957, p. 106). As a consequence, while MI is centered on the idea of autonomy (i.e., individual self-determination), which is often linked to that of unintended consequences, holism is centered on the idea of heteronomy (which means historical and sociological determinism in the sense of hidden control of the social dynamics by supra-individual forces).

During the Enlightenment, the anti-theistic eagerness to affirm that individuals and their actions are the ultimate causes of social phenomena was sometimes accompanied by the tendency to support social atomism (see Hayek, 1978, p. 3; Petitot, 2002; 2012, p. 210; 2016). As stressed by Hayek (1948, p. 1-32), two individualist approaches can be distinguished: one supported by the Scottish Enlightenment, the other supported by the Continental Enlightenment. The former (think, for example, of the works of David Hume (1711-1776), Adam Ferguson (1723-1816), and Adam Smith (1723-1790)) was a non-atomistic and systemic approach, which acknowledged the autonomy of the individual, but also the existence of socio-cultural constraints. The second led to the development of a number of atomistic theories of the social contract at that time. These atomistic theories were linked to a mechanist philosophy, according to which society is nothing but the sum of individual atoms (*ibid.*). As a reductionist approach, this atomistic philosophy left no room for a systemic social science (see Di Iorio, 2015, p. 81).

Today the atomistic version of MI is employed by social contract theory and large sectors of the economic sciences – namely, conventional or orthodox economics. Like the old atomism, new atomism is, because of its assumptions, unrealistic and neglects in many ways social conditioning (see Di Iorio, 2015, pp. 75-115; see also O'Driscoll and Rizzo, 1995). After the Enlightenment the non-atomistic variant of MI was developed by most individualist sociologists, the Austrian School of Economics, and some philosophers such as Karl Popper. This variant conceives of society in an emergentist and systemic way and of the agent as being influenced by many structural and socio-cultural factors that limit his/her

consciousness. Regarding the influence of Marx's ideas on various sociological and philosophical holistic traditions, see Boudon (1994) and Popper (1945b; 1957).

freedom (see Boudon, 1971; 2013; Bouvier, 2011; Demeulenaere 2011; Di Iorio, 2015; 2016b; Di Nuoscio, 2018; Hayek, 1948; Manzo, 2014; Petitot, 2016; Rainone, 1990). As understood by this second variant, MI is consistent with the reference to irreducible concepts and explanations.

The non-atomistic variant of MI often explains the structural constraints that affect individual actions (such as the constraints linked to generally accepted dress codes or constraints linked to high market prices) in terms of unintended consequences produced by shared beliefs and rules. Moreover, it assumes that the endorsement of these beliefs and rules by the agents can be understood through an interpretative approach. As we will explain in the next section, central to this variant is also a concept of circular causality in the sense of downward and upward causation. Since it is anti-atomistic, this variant of MI is based on the idea of human autonomy (i.e., human self-determination), not in the sense that it supports absolute freedom from structural constraints (only atomism is committed to absolute freedom), but because it assumes that the influence of structural constraints on the agent is never mechanical in the sense that it cannot be studied without understanding the way this influence is interpreted by the agent (Bulle, 2018; Bulle and Phan, 2017; Di Iorio, 2015; 2016b). This point must be kept in mind to understand in which sense this non-atomistic variant argues that the ultimate causes of social phenomena, including social conditioning and structural constraints, must be sought in the individual rather than in holistic supra-individual forces that mechanically determine his/her actions.

Although the atomistic variant of MI, unlike the non-atomistic one, is rooted in a mechanistic philosophy that is reductionist, it did not provide explanations that can be considered, strictly speaking, to be reductionist. This is because reductionist social explanations – ones that do not refer at all to systemic properties and laws - are simply impossible (see Boudon, 1971; Bulle, 2018). The atomistic variant of MI does not consider many socio-cultural constraints, but cannot neglect all of them. For example, even if the eighteenth-century social contract theories are linked to a reductionist philosophy, they assume implicitly the existence of some socio-cultural systemic constraints. One only has to consider that, as an agreement, a social contract presupposes a shared language: a system of rules that implies structural constraints that affect human freedom (see Di Iorio, 2015, p. 115; see also Boudon and Bourricaud, 1990, pp. 387–388, Petitot 2009, pp. 102 ff.). In other words, the atomistic variant of MI can be meaningfully regarded as reductionist only in the sense that it is more or less

committed to a mechanistic philosophy that is reductionist, but not in the sense that this variant developed real reductionist explanations.

The dominant interpretation of MI in terms of reductionism suggests rejecting the distinction between the atomistic and the non-atomistic variant of MI and regarding the entire individualist tradition as reductionist, i.e., as incompatible with emergentist and systemic approaches that acknowledge various structural constraints limiting individual freedom (see Kincaid, 1986, Udehn, 2011). In our opinion, because of the reasons stressed above, this interpretation is, despite its popularity, inaccurate and does not match the actual historical reality about MI (see Bouvier, 2011; Bulle, 2018; Demeulenaere, 2011, p. 11; Di Iorio, 2015, pp75 ff; 2016a; 2016b; Jarvie, 2001, pp. 117 ff.). The confusion about MI which is widespread today originated in the Mandelbaum-Watkins debate on MI – a debate on which analytic philosophers built their interpretation of MI in terms of reductionism (see Mandelbaum, 1955; Watkins, 1955; see also Rainone, 1990). John Watkins' defense of MI against Maurice Mandelbaum's criticism was ineffective because he did not seem to correctly understand the latter's point. Assuming that MI equals reductionism, Mandelbaum (1908-1987) argued that MI must be rejected because reducing the vocabulary of social concepts and explanations to the vocabulary of individual concepts and properties is impossible. In rebutting Mandelbaum's criticism of MI, Watkins (1924-1999) did not really engage with this argument. He insisted over and over again on the shortcomings of holism as traditionally understood by MI and on the preferability of MI to socio-historical determinism (see Rainone, 1990). Since Watkins did not provide valid arguments against Mandelbaum's line of reasoning, subsequent debates on MI in analytic philosophy took for granted that Mandelbaum was right about the reductionist nature of MI. This is also because these debates neglected a careful historical analysis of the reflections and explanations provided by the supporters of MI.

This is, however, not the place to analyze in detail the differences between the atomistic and non-atomistic variant of MI. There are a number of works in which that difference has been clarified and we refer the reader to this literature (see, for instance, Boudon, 1971, Demeulenaere, 2011; Dupuy and Dumouchel, 1983; Di Iorio, 2015, 2016a, 2016b; Di Nuoscio, 2018; Hayek, 1948; Jarvie, 1972, 2001; Laurent, 1994; Nadeau, 2016; Popper, 1957, 1966a, 1966b; Petitot, 2016; Campagnolo, 2016). The point that we would like to stress here is related to what Marchionni and Ylikoski call the conceptual confusion that can be caused by arguing that MI and ABS are compatible because, while ABS is a non-reductionist

approach, the dominant interpretation of MI assumes that MI is reductionist. The risk of confusion is real but, in our opinion, it can be avoided without breaking down the association between ABS and MI by stressing that there are two different variants of MI and taking care to define ABS as non-reductionist MI rather than simply as MI.

4. Semantic Reductionism and Idealist Reductionism

It is time to analyze in more detail in which sense MI is considered to be reductionist and incompatible with the systemic analysis of social phenomena within large sectors of contemporary philosophy. In the previous section, we argued that the dominant interpretation of MI is wrong from a historical standpoint because it fails to distinguish between two different variants of MI, but we did not carefully focus on the methodological and logical reasons why this interpretation cannot be applied to the non-atomistic variant of MI. In this section we shall try to fill this gap. Moreover, we shall consider some examples of explanation in terms of non-atomistic MI that support our view that this approach is at odds with reductionism and compatible with the ABS strategy.

As stressed by Marchionni and Ylikoski, the view that the entire individualist tradition is reductionist is defended by various critics of MI, among them Kincaid (1986; 1996), Pettit (1993) and Udehn (2001). Kincaid and Pettit's interpretation of MI is similar to Udehn's, but not identical. Kincaid and Pettit, as well as many other analytic philosophers (e.g., Lukes, 1968; 1973; Sawyer, 2002; 2003), theorized an interpretation of the individualist tradition in terms of *semantic reductionism*, while Udehn and others (e.g., Archer, 1995; Bhaskar, 1979) supported an interpretation of that tradition in terms of *idealist reductionism* (see Di Iorio, 2015, 2016a: 2016b).

According to the interpretation of MI in terms of semantic reductionism, explanations in terms of MI are based on the principle that social properties are semantically reducible to individual ones (for more details on this see Di Iorio 2015, pp. 105 ff.). On this interpretation, MI must be rejected because:

- (i) the semantic reducibility of social properties, which are systemic and non-strictly individual, is impossible as showed by various arguments provided by philosophers and systems theorists. One of the most famous arguments against this reducibility is the multiple realization problem (see Kincaid, 1986);

- (ii) supporting semantic reducibility means denying the obvious truth that social properties causally influence action in the sense that they limit human freedom (see Di Iorio, 2016, p. 105).

To further elaborate, critics of MI who interpreted MI in terms of semantic reductionism assumed that MI is incompatible with the old idea that a society is more than the sum of its parts. They reaffirmed this old idea focusing on the analysis of language and explaining that the vocabulary about social properties cannot be replaced by the vocabulary about individual properties. Consider, for example, the following sentence: “Nation X is richer than nation Y”. This sentence, which refers to social properties, cannot be semantically reduced to a set of predicates concerning properties of individuals “because it does not entail that any member of nation X is richer than any member of nation Y” (Di Iorio, 2015, p. 105; also see Di Nuoscio, 2018). Similarly, since all explanations about social conditioning and structural constraints refer to social properties, these explanations cannot be semantically reduced to a set of predicates concerning properties of individuals. As a consequence, no reductionist approach can account for the influences of the social environment and its systemic properties on action.

The interpretation of MI in terms of semantic reductionism cannot be applied to what we have referred to above as the non-atomistic variant of MI, at least for the following three reasons. First, it is because of the central relevance that the non-atomistic variant attaches to the notion of unintended consequences of human action. As we shall also clarify later, explanations in terms of unintended consequences cannot be regarded as reductionist explanations because they refer to emergent properties semantically irreducible to the individuals’ mental and behavioral properties (see Di Iorio 2015, 2016; Hayek 1952). Second, advocates of the non-atomistic variant of individualism such as Friedrich Hayek (1899-1992), Karl Popper, James Coleman (1926-1995) and Raymond Boudon (1934-2013) openly rejected semantic reductionism and regarded the assumption that a society is semantically more than the sum of its parts as trivially true (for more details about this see Di Iorio, 2015, p. 94; 2016a; see also Boudon, 1971; 1998; Hayek, 1967, 60; Popper, 1957, p.82, Coleman, 1990, p. 5). Third, non-atomistic MI acknowledged the existence of emergent properties that causally influence individuals and create systemic constraints that limit their freedom. The history of MI and of the empirical explanations provided by its advocates offers countless examples of this (see Boudon, 1971; Bouvier, 2011). The analytic philosophers who criticized MI developed refined arguments

against MI understood as semantic reductionism, but neglected that, since reductionism has been supported only by the most simplistic variant of MI, arguments against reductionism do not undermine MI.

One example of the wrongness of the assumption that MI equals semantic reductionism is the analysis of the price system as a cybernetic system developed by the two famous methodological individualists Friedrich Hayek and Ludwig von Mises (1981-1973) (see Hayek 1948, 1973; Mises, 1922). According to these two Austrian economists, who challenged conventional economics and its unrealistic and atomistic presuppositions, market prices are semantically irreducible to psychological and individual properties because those prices are systemic effects that unintentionally emerge from the aggregation of different individual evaluations. For Mises and Hayek, market prices, which reflect distributed information and presuppose a set of legal constraints related to private law and private property, allow the coordination of economic activities insofar as they limit the freedom of choice of individuals, who need to consider price variations because of their budget limitations. In Mises' and Hayek's opinion, economic coordination is made possible by a spontaneous mechanism or self-organizing process centered on the fact that market prices, which are emergent effects unintentionally created by human choices, in turn affect these choices. According to Mises and Hayek, because of the price mechanism the whole economic system causally influences its parts, and vice versa, and via this circular causality there is a spontaneous adaptation of the local to the global and the global to the local. This is an example of downward/upward causation (cf. Bouvier, 2011; Di Iorio, 2016a; Petitot, 2016). Hayek (1967; 1973; 1978) describes the market system as a complex self-organizing system (see also Caldwell, 2007, p. 363 ff.; Dupuy and Dumouchel, 1983; Petitot, 2016).²

Mises and Hayek's analysis of market prices is based on the approach of another famous non-atomistic methodological individualist, Carl Menger (1840-1921), who was the originator of the Austrian School of Economics, to which Mises and Hayek belong. As understood by Menger (1985, p. 142), MI assumes that human actions must be considered to be parts of a global structure or system (see Campagnolo, 2013; 2016) and that "social structures ... in respect to their

²As stressed by Caldwell (2007, p. 363), "anyone who has read...[Hayek] will be startled on encountering recent work in agent-based computational economics or 'artificial society modeling,' for it all seems so familiar". Caldwell (ibid., pp. 363-366) showed, in particular, the similarities between the approach developed by Epstein and Axtell (1996) in their book *Growing Artificial Societies: Social Science from the Bottom Up* and the theory of markets supported by Hayek and the other members of the Austrian school of economics committed to the non-reductionist variant of MI. For a detailed analysis of those similarities, we suggest that the reader refer to Caldwell (ibid., pp. 362-366 and pp. 367-368); see also Vriend (2002) and Gräbner (2016).

parts are higher units”. According to Menger, these structures are endowed with “functions” that “are vital expressions of these structures in their totality” (ibid., p. 139). From his standpoint, society is a structure or system because each part of it – each individual or each social subsystem (say, a firm) – “serves the normal function of the whole, conditions and influences it, and in turn is conditioned and influenced by it in its normal nature and its normal function” (ibid., p. 147).

Various examples of systemic explanation in terms of methodological individualism can also be found in the works developed by supporters of the rational choice model (RCM) in sociology, namely, Coleman (1990) and his precursors (see Raub and Voss, 2017). As stressed by Raub and Voss (2017, p. 7), these authors, who influenced the development of analytical sociology, aimed “at the explanation of social phenomena at the macro-level by employing hypotheses on individual behavior as well as assumptions on how macro-level phenomena affect individual behavior and the macro-outcomes of individual behavior”. Some supporters of the RCM paid special attention to the relation between RCM and ABS, arguing that the latter is an implementation of MI (e.g., Flache & Macy, 2009).

Now, let us turn to the interpretation of MI in terms of idealist reductionism. This interpretation, which is supported by Udehn (2001) and others – namely, critical realists such as Archer (1995), Bhaskar (1979), and Lawson (1997) – is based on a misunderstanding of the interpretative approach (*Verstehen*) of MI. According to this interpretation, since MI, especially in its sociological versions, is based on the study of the subjective meaning that the individual attaches to his/her actions, the adoption of MI is equal to denying that structural constraints on action are real and objective. In other words, the problem with MI is that these constraints cannot be accounted for by focusing on the agent’s subjective viewpoint because these constraints exist independently of the agent’s opinion about what he or she is free or not free to do (see Di Iorio, 2015, pp. 103-105; 2016; King, 2004). For example, if a French tourist who visits New York City for the first time does not know that drinking alcoholic beverages on the street is forbidden there, this does not alter the fact that if he/she drinks alcoholic beverages on the street and the police see him/her, the police will intervene. According to the interpretation of MI in terms of idealist reductionism, MI must be rejected because it is a form of anti-realism that does not understand this problem. MI cannot account for the fact that the individual is embedded in a social structure which is characterized by a set of rules, sanctions, and social

positions that are objective and real in the sense that they exist independently of the agent's viewpoint.

The interpretation of MI in terms of idealist reductionism cannot be applied to the non-reductionist variant of MI because, contrary to what Udehn and critical realists argue, that variant assumes that strictly subjective opinions “are not the basis of social life” (King, 2004, 190). As largely stressed by authors such as Weber, Hayek and Boudon, non-reductionist MI “explains the social world and the constraints that this world imposes on individuals in terms of shared meanings and of unintended consequences related to these shared meanings” (Di Iorio, 2016, p 368). In explaining the foundations of the social world, the non-atomistic variant of MI does not apply its interpretative approach (*Verstehen*) to strictly subjective opinions, but rather to common meanings; and it explains social constraints and social sanctions as objective (and sometimes brutal) consequences of these common meanings, i.e., of a set of “collective beliefs” (Boudon, 2001). As highlighted by Hayek (1952, p.34), social systems must be regarded as “the implications of many people holding certain views,” that is, as “the consequences of the fact that people perceive the world and each other through sensations and concepts which are organized in a mental structure common to all of them”. The application of the interpretative approach of MI to collective beliefs and the analysis of the unintended consequences related to these beliefs allows us to explain any kind of structural constraint in Udehn's sense. For example, Weber (1946, pp. 396-415) explained the existence of the caste system in India and strong ritual constraints related to this system as a largely unintentional consequence of common or shared magical and religious beliefs.

5. From Ontological Individualism to Bottom Up Explanations and Systemic Analysis

In our opinion, the dominant interpretation of the individualist tradition as a whole in terms of reductionism is mistaken not only because it argues that MI is incompatible with a bottom-up and systemic approach, but also because it misunderstands the relationship between ontological individualism and explicative individualism. As stressed by Marchionni and Ylikoski (2013, p. 10), according to the dominant interpretation, MI “is a thesis about explanation, not about ontology” (see also Lukes, 1973). Even regarding this point, the dominant interpretation seems to us to be historically inaccurate. In this section, we will

analyze the ontological assumptions of the non-reductionist variant of MI and show that they are a good match for both the ABS strategy and the concept of downward/upward causation.

Many non-reductionist individualists such as Carl Menger, Max Weber, Georg Simmel (1858-1919), Herbert Spencer (1820-1903), Ludwig von Mises, Friedrich Hayek and Karl Popper argued that MI is based on ontological individualism (see Antiseri, 2007; Di Nuoscio, 2018; Pribram 2008)³. Ontological individualism, which is also referred to as nominalism, is a metaphysical theory about the nature of social wholes expressed by collective nouns such as “state”, “market”, “army”, “class”, “society” and “bureaucracy”. According to ontological individualism, collective nouns do not correspond to effective or concrete realities (substances) because they are only synthetic ways to conveniently describe a set of individuals (whose interaction produces emergent and systemic properties). In other words, ontological individualism assumes that collective nouns do not refer to things that “exist independently of the individuals which compose them” (Hayek, 1948, p. 6). According to ontological individualism, while the word “individual” does correspond to a real entity, collective nouns such as “capitalism” or “society” do not, in the sense that they refer to a collection of individuals and the consequences of their interaction (which must be described in systemic terms). As stressed by Hayek (1952, p. 54), in dealing with collective nouns one should avoid committing “the mistake...of treating as facts what are no more than vague popular theories”, i.e., commonsense views that naively hypostatize social wholes. This mistake is referred to by Hayek as “the fallacy of ‘conceptual realism’ or, by using a term made famous by A. N. Whitehead (1861-1947), “the fallacy of misplaced concreteness” (ibid.).

Methodological individualists, or at least many of them, consider holism as being based on a mistaken theory about the nature of collective nouns (see Pribram, 2008). According to this theory, which is called ontological holism or realism, collective nouns must be treated as real substances that exist independently of individuals such as, for example, a flower or a stone (see Antiseri, 2007; Di Nuoscio, 2018). Holism, understood as a method based on realism, assumes: (i) that individuals are irrelevant from an ontological and explicative standpoint because they are derivatives of social wholes understood as concrete entities; (ii) that what matters is ultimately the study of how those social wholes determine human thoughts and actions. An example of holism

³ Some methodological individualists such as Raymond Boudon preferred to not get involved in ontological debates and never explicitly endorsed ontological individualism.

understood in these terms is the deterministic relationship between the economic structure and the individual consciousness in the work of the Marxist thinker Louis Althusser (1918-1990) (see Boudon and Bourricaud, p. 1990). As stressed by Popper (1957, 1966a, 1966b) and Hayek (1952), holism is the theory that social sciences should explain social wholes (understood as concrete supra-individual entities), their own laws of functioning and evolution so as to unveil the hidden determinants of consciousness and action.

Note that this definition of holism is very different from the one provided by critics of MI who interpret MI in terms of reductionism. These authors assume that, from a historical standpoint, the main feature of holism is its commitment to a systemic and non-reductionist approach and that this is why holism is at odds with MI (see, for example, Kincaid and Zahle, 2019). However, as stressed in Section 3, this is incorrect. This view is historically inaccurate because the traditional individualism-holism debate was not centered on reductionism, but on the nature of the ultimate causes of history and social dynamics.

One of the reasons why non-reductionist individualists regarded holism as mistaken was that they considered it to be incompatible with a real systemic analysis (see Hayek, 1952). According to holism as understood by non-reductionist MI, the method of the social sciences cannot be described in terms of a bottom-up strategy of explanation. From the standpoint of this concept of holism, the problem is not explaining emergent social phenomena in terms of unintentional consequences of human intentions because human intentions are irrelevant and social phenomena are produced by hidden deterministic social mechanisms that control the individuals and their minds (see Di Iorio, 2015). According to holism in the sense specified here, the ultimate causes of social phenomena are located in social wholes understood as concrete entities. This stance is at odds with emergentism. This is because only an approach based on an individualist ontology, which denies the existence of supra-individual entities that control the agents, can locate the ultimate causes of social phenomena in the individuals and support a bottom-up strategy of explanation (see Di Iorio, 2015, 2016a, 2016b; Petitot, 2016). If the ontological and causal relevance of individuals is denied and individuals are regarded as remote-controlled by holistic social entities, no bottom-up strategy is possible and social phenomena cannot be explained in terms of circular causality between micro and macro factors, i.e., in terms of downward/upward causation (see Petitot, 2016).

Unlike what Steven Lukes and other supporters of the dominant interpretation of MI have stated, the (non-reductionist) methodological

individualists assumed, as explained above, that the acceptance of their individualist approach and its bottom-up and emergentist explicative strategy is a corollary of the rejection of ontological holism in the name of ontological individualism (see Antiseri, 2007; Di Iorio, 2015; Di Nuoscio, 2016, 2018, Hayek, 1952; Bulle and Phan, 2017; Petitot, 2016; Di Iorio, 2015; Di Iorio and Herfeld, 2017)⁴. The view that MI “is a thesis about explanation, not about ontology” (Marchionni and Ylikoski, 2013, p. 10) is historically inaccurate.

This point needs to be considered to correctly understand the relationship between ABS methodology and MI. In the light of a proper analysis of the links between ontological and methodological individualism it becomes clear that ABS and MI share the same assumptions. For both of them, individuals matter and to develop a correct systemic analysis of social phenomena action cannot be explained in deterministic terms. Both ABS methodology and MI are at odds with the ontological and methodological assumptions of holism as understood by MI (regarding the incompatibility between ABS and holism in this sense see Gräbner, 2016). As argued by Menger (1985, p. 133), from the standpoint of MI, social systems, which are composed of individuals, cannot be regarded as deterministic machines because these systems “cannot be viewed and interpreted as the product of purely mechanical force effects. They are, rather, the result of human efforts, the efforts of thinking, feeling, acting human beings.”

In our opinion, the systemic approach supported by the non-reductionist variant of MI, which is linked to a nominalist ontology, is essentially not different from the approach referred to as “systemism” by Mario Bunge (Bunge, 2000; see also Gräbner and Kapeller, 2015; Gräbner, 2016) – an approach that is well accepted in both the ABS and the complex system science community. According to systemism, good social scientists “do not study individuals, except as components of social systems” (Bunge, 2000, p. 154). Moreover, these scientists assume that individuals matter and do not act in a deterministic way as remote-controlled agents. Like Kincaid and Udehn, Bunge criticized MI and maintained that the entire individualist tradition is atomistic or reductionist. In his opinion, systemism must be regarded as a new methodological approach that rejects both

⁴Nominalism is compatible with the assumption that collective nouns have causal power. Consider the following explanation. Soccer team A won against soccer team B because of its better tactical organization, even though soccer team A’s players were less talented than soccer team B’s. The reason why explanations of this kind, which refer to systemic properties and their causal power, are compatible with nominalism, is that they entail neither that collective nouns (e.g., soccer team A) are substances that exist independently of the individuals that compose them, nor that collective nouns control human actions (e.g., soccer team A’s players’ decisions). On the relationship between the causal power of irreducible global properties and ontological individualism see Popper (1957; 1977).

reductionism and the holistic view that individuals are irrelevant. While we agree with Bunge's systemic methodology and the importance he attaches to individuals, we disagree with his criticism of MI. In our opinion, what he calls systemism must be regarded as an old approach rather than as a new orientation. As we have tried to show in Sections 3, 4 and 5, MI, or at least a variant of it, supported systemic analysis "since the very beginning" (Demeulenaere, 2011, p. 11).

According to authors such as Menger, Weber, Simmel, Popper, Mises, and Hayek, nominalism and systemic analysis are two sides of the same coin. This is because, in their opinion, any collection of individuals is necessarily characterized by systemic properties and cannot be studied in atomistic terms, i.e., by making abstractions of these fundamental properties (see Di Iorio, 2015, pp. 75 ff. and Popper, 1957, p. 82). The fact that these authors described their approach as strictly related to the theory of the unintended consequences of the human action depends precisely on their commitment to an anti-reductionist view of the social world. As we shall clarify in Section 8, explanations in terms of unintended consequences are about systems and emergent phenomena.

6. Non-Individual Agents

To conclude our analysis of the relationship between MI and the ABS strategy, we must consider two more points which are strictly related to the arguments developed above against the view that the connection between ABS and MI must be broken down because, while ABS develops emergentist and systemic explanations, MI is incompatible with this kind of explanation.

The first point is about the fact that, as stressed by Marchionni and Ylikoski, according to ABS, agents can also be non-individual agents, i.e., households, groups, factories, organizations and so on (Marchionni and Ylikoski, 2013, p. 13). Given the interpretation of MI in terms of semantic reductionism, this means that "ABS is not by itself individualistic" (ibid.). On this interpretation, explanations that refer to non-individual agents are incompatible with MI because this approach aims at developing explanations that solely refer to strictly individual properties and laws. We reject this view because, as demonstrated above, MI, or at least its non-atomistic variant, must not be confused with semantic reductionism. Explanations that refer to non-individual agents are compatible with the non-reductionist variant of MI. They are such insofar as they do not

conceive non-individual agents in holistic terms, i.e., as supra-individual substances (concrete entities) that ontologically exist independently of the individuals and control their thoughts and actions (see Di Nuoscio, 2018; Nadeau, 2016). The fact that ABS methodology sometimes refers to non-individual agents is not a sufficient condition to conclude that ABS is incompatible with MI⁵.

Non-reductionist methodological individualists have provided many examples of explanations in terms of non-individual agents (understood in non-holistic terms). Consider, for example, Coleman's concept of "corporate agents" (Coleman, 1990, 325 ff), Spencer and Hayek's analyses of cultural evolution in terms of "group selection" (see Di Nuoscio, 2016) and Kirzner's concept of a "corporate firm" (Kirzner, 1978, 63ff) that is similar to the concept of firms extensively used in agent-based computational economics (Arifovic, 1994; Chen and Ni, 2000). The reference to non-individual agents is simply indispensable in the analysis of many social phenomena. As stressed by Bulle and Phan (2017, p.3), following Boudon (2007),

methodological individualism does not exclude that under certain conditions, a collective entity might be legitimately treated as an individual, for example, a group, such as a government or a political party, equipped with procedures allowing it to transform the individual opinions of its members into collective decisions issued in their name.

We shall use Arifovic (1994) as an illustration of the fact that non-individual agents as conceived by ABS are not holistic entities and that ABS is an implementation of non-reductionist MI. Arifovic (1994) provides an analysis of price dynamics; here, what needs to be accounted for are observed price fluctuations or price instability. In ABS, as mentioned earlier in the paper, the price is an emergent phenomenon, and in this context it emerges from firms' beliefs, objective functions, cost conditions, and their interactions with other firms and consumers. Arifovic provides two different models in her analysis; one has three levels (micro-meso-macro), and one has two levels (micro-macro). In the three-level case, she begins with an individual decision maker, say, a CEO in a firm, and then moves up to a firm, which is a collection of individual CEOs, and

⁵ In fact, this point can be driven away. 'Individual' per se is not independent of the level or granulation chosen in our analysis; for example, to analyze the stock market bubbles, should we start from neurons or from decision makers? This issue has been well pointed out since the influential paper by Herbert Simon (Simon, 1962), but its relevancy to agent-based modeling was first addressed by Davis (2013) and further by Chen (2016). Nonetheless, despite its diverging points, once the level or the granulation is fixed, the 'bottom' is determined, and then the bottom-up mechanism is operated and demonstrated from there, through agent-based modeling (Tsfatsion, 2001). Also see the Appendix.

further up to a market; but in the two-level case, she skips the “internal process” of the firm and directly starts the analysis from the firm. The upshot is to show that we can basically reach the same results of price dynamics either starting from individuals (the three-level ABS) or starting from firms (the two-level ABS). In other words, if our interest is only in price dynamics, we may ignore the internal interactions of a firm’s behavior and take the firm as a given emergent entity and start the analysis from this level. Hence, Arifovic’s analysis provides a good illustration of the point of ontological individualism which we address in Section 5. In her two-level case, a firm is a collective entity, but it is not conceived of as supra-individual substances that ontologically exist independently of the individual CEOs and control their thoughts and actions; instead, in light of the contrasting three-level model, it can be perceived as a result of the interactions of a myriad of CEOs. The point that the three-level model can be simplified into the two-level one is that if corporate profits are consistent with CEO earnings, which normally is the case, then the three-level model may not provide us with more information than the two-level model does insofar as the price dynamics is the main concern.

The juxtaposed treatment of the two-level and the three-level analysis, as exemplified by Arifovic, has been commonly seen in ABS. Using genetic algorithms (GA) as a major ABS tool, Holland and Miller (1991) distinguish the two-level analysis from the three-level analysis by introducing two variants of GA, namely, population GA and individual GA. Whether an individual decision maker should be taken as the starting point of analysis is then constantly pursued by the ABS community. In the context of monopolistic competition, Vriend (2000) provides an example showing that the two-level models and the three-level models may lead to a different market equilibrium. Nevertheless, in agent-based financial markets, one of the most active areas in ABS, we find little evidence to support the difference between the two-level and three-level models. For example, the market dynamics generated by the foreign exchange market, as modeled either by the two levels or three levels, are qualitatively the same (Izumi and Ueda, 2001; Manzan and Westerhoff, 2007). For our purposes, the point here focuses not on the choice of the two- or three-level models per se, but on the use of literature to illustrate that according to the ontological individualism as reviewed in Section 5 one can find many examples in the practice of ABS, i.e., a non-reductionist variant of MI.⁶

⁶ For more the interested reader is referred to the Appendix.

7. The Micro-Macro Problem: ABS and Unintended Consequences

The last point that we must consider is that, given the dominant interpretation of MI in terms of reductionism, another argument that can be offered against associating ABS with MI is that, while the former is supposed to solve micro-macro problems, MI cannot (see Marchionni and Ylikoski 2013, p.14). Indeed, a reductionist approach can explain neither the emergence of systemic macro-phenomena from the individual level, nor the retroaction of the macro level on the individual one. In our opinion, this argument against associating ABS with MI must be rejected because, as argued above, the non-reductionist variant of MI was developed precisely to solve micro-macro problems in a scientific way against the tendency to account for them in religious terms. This variant of MI is a useful tool for analyzing these problems because it is a systemic approach centered on the concept of unintended consequences and the study of social phenomena in terms of downward/upward causation (see Bouvier, 2011; Manzo, 2014). The explanation of the market in terms of a self-organizing complex system developed by Hayek following Menger and Mises that we mentioned above is a good example of this. Another example of analysis of a micro-macro relation linked to a feedback process in terms of MI is Weber's argument that the unintentional development of Capitalism in Northern Europe due to the Protestant Ethic considerably altered people's everyday lives because it led to a kind of involuntary servitude to mechanized industry which is typical of modern and rationalized society (Weber, 2005, p. 181). As shown by Spencer (1996, p. 403), the non-reductionist variant of MI can be applied even to explain the emergence of language and "all its leading structural traits" and binding rules, which are an example of downward causation (also see Di Nuoscio, 2018). This emergence can indeed be regarded as an unintended consequence produced by "the need to communicate" (Spencer, 1996. p. 403). According to Spencer (ibid.), "little by little men developed speech in absolute unconsciousness that they were doing anything more than pursuing their personal interests". Before the existence of language, it would have been impossible to invent the language by social contract because no agreement is possible without a language. For this reason, Spencer (1996, p. 402) argues that, without the concept of unintended consequences, which is central to MI, we would be obliged to consider language as a "miraculous gift" of "supernatural origin". In other words, we would not have

been able to understand scientifically the spontaneous emergence of language from the micro-level.

Solving micro-macro problems is thus a common goal for both MI and the ABS strategy. However, while MI describes the micro-macro link by especially using the concept of unintended consequences, ABS methodology does not refer very often to this concept. Regarding this point, the difference between MI and ABS seems to us to be more in terms of words rather than of things. The idea of generating macro outcomes from the bottom up (i.e., from the micro-level), which is central to the ABS strategy, is largely about what MI calls unintended consequences (see Elster 1989). Some supporters of ABS methodology such as, for example, Nan, Johnston and Olson (2008), Linares (2018), Manzo (2013), and Squazzoni (2014) are clearly aware of the link between generation and unintended consequences. As stressed by Linares (2018), foundational works in ABS methodology (e.g., Holland, 1996; Axelrod, 1997; Epstein and Axtell, 1996; Poteete, Janssen and Ostrom, 2010), which aim at explaining complex adaptive systems, share various methodological assumptions of the old theory of the unintended consequences. Following Linares (2018), it can be said that the following common assumptions are shared by MI and the ABS strategy: (i) the idea of “emergence”, i.e., the idea that “there is no clear connection between the properties of the whole and the properties of the parts” (Linares, 2018, p. 28); (ii) the principle that “actions of agents can, and tend to have non-linear consequences” (Ibid.); (iii) the existence of “cumulative processes” that produce macro-outcomes that retroact on the micro-level or local level (Ibid.); and (iv) the idea that “internal dynamics” of complex systems “do not tend to be the result of centralized planning or direction, but rather the result of self-organizing dynamics” (Ibid.).

8. Conclusion

In an article recently published by the *Journal of Classical Sociology*, Bulle (2018, p. 1) argued that the “importance of methodological individualism (MI) for explanation in the social sciences and the breadth of controversy surrounding it are only equaled by the misunderstandings of which it has been, and still is, the object”. In her opinion, if MI were really a reductionist approach, “we can be sure that MI would not have merited the interest it aroused or even the slightest discussion” insofar as, as is often stressed, reductionism is clearly impossible (Ibid.)

In this article, by using an article by Marchionni and Ylikoski (2013) as the starting point of our analysis, we have focused on the view that MI is incompatible with the ABS strategy because MI is committed to reductionism, while the latter is not. We have argued that this view does not hold because the widespread interpretation of MI in terms of reductionism is historically incorrect and must be rejected. We have maintained that reductionism is supported only by the most simplistic variant of MI and have clarified that ABS explanations must be regarded as explanations in terms of non-reductionist MI. In our view, the latter variant of MI is a good match for the methodological assumptions of the ABS strategy, namely, the systemic approach of this strategy and its commitment to the idea of downward/upward causation.

Appendix: Modularity and Microsimulation

In this appendix, we provide some additional remarks for Section 6, specifically regarding the use of non-individual agents in ABS. First of all, we notice that ABS, as distinguished by the two-level analysis or three-level analysis, as well illustrated in Section 6, can be generalized if the computational capacity can be sustainably expanded (see Chen, 2016, Chapter 25). If that happens, then we are actually facing the issue of the choice of the elementary analytic level, first raised by Herbert Simon (Simon, 1962). Very much like Hayek, Simon's legacy is also considered intrinsically related to ABS (Chen, 2005, 2016b; Chen and Kao, 2016). Simon's partial solution to this problem is that the complex system has a feature known as near decomposability or near modularity. This modularity determines where we can encapsulate a unit in the sense that all its details can be ignored if we want to understand just the macro properties. The relevance of the modularity principle to agent-based modeling was first addressed by Davis (2013), and is called the Simon-Davis criterion (also see Chen, 2016, Chapter 25). This criterion basically says that, if the system to which agent-based modeling is applied is modular, then the ABS structure can be simple, which, based on our understanding, is probably related to the reductionist variant of MI, but if the system to which the agent-based modeling is applied is close to being modular or even non-modular, then the structure can be complex and is related to the non-reductionist variant.

Also related to the discussion here is the distinction between microsimulation and agent-based simulation, as a two-generation development in simulation.

Microsimulation was proposed by Guy Orcutt (1917-2006) in the late 1950s (Orcutt, 1957). This approach was then used in the social sciences for a long while, before ABS burgeoned in the 1990s. Interestingly enough, before the neologism “agent-based simulation” was invented, there was a period when ABS was mixed with microsimulation due to insensitivity to their essential differences. Nevertheless, as time has gone on, their non-trivial differences have become clear. While both microsimulation and agent-based simulation follow a bottom-up mechanism, the former does not involve substantial interactions among individuals, and hence the bottom-up phenomenon is more like a linear adding-up rather than an emergent property or explanation of generations. Furthermore, it generally lacks downward causation, and no circular causality; hence, in the vein of Simon (1962), it is similar to the idea of the application of ABS to a modular system. To rephrase their differences in our context, we can say that microsimulation is closer to the reductionist version of MI, whereas ABS is closer to the non-reductionist version of MI.

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References

- Antiseri, Dario. 2007. *Popper's Vienna*. Aurora, CO: The Davies Group Publishers.
- Archer, Margaret. 1995. *Realist Social Theory: The Morphogenetic Approach*. Cambridge: Cambridge University Press.
- Arifovic, J. (1994). “Genetic Algorithm Learning and the Cobweb Model.” *Journal of Economic Dynamics and Control*, 18(1), 3-28.
- Axelrod, Robert. 1997. *The Complexity of Cooperation. Agent-Based Models of Competition and Collaboration*. Princeton, NJ: Princeton University Press,
- Bhaskar, Roy. 1979. *The Possibility of Naturalism*. Sussex: Harvester.
- Boettke, Peter, and Rosolino Candela. 2015. “What Is Old Should Be New Again: Methodological Individualism, Institutional Analysis and Spontaneous Order.” *Sociologia*, 2:5-14.
- Boudon, Raymond. 1971. *Uses of Structuralism*. London: Heinemann.
- Boudon, R. 1994. *The Art of Self-persuasion*. Cambridge, UK: Polity Press.

- Boudon, Raymond. 1998. *Social Mechanisms without Black Boxes*. In Peter Hedström and Richard Swedberg (eds.) *Social Mechanisms: An Analytical Approach to Social Theory*. Cambridge: Cambridge University Press.
- Boudon, R. 1994. *The art of self-persuasion*. Cambridge, UK: Polity Press.
- Boudon, R. 2001. *The Origins of Value*. Piscataway, NJ/London: Transaction Publishers.
- Boudon, R. 2007. *Essai sur la théorie générale de la rationalité*. Paris: Presses Universitaires de France.
- Boudon, Raymond. 2013. *Sociology as Science: An Intellectual Autobiography*. Oxford: The Bardwell Press.
- Boudon, R., and F. Bourricaud. 1990. *A critical dictionary of sociology*. Chicago, IL: University of Chicago Press.
- Bouvier, Alban. 2011. "Individualism, Collective Agency and the 'Micro–Macro Relation'." In *The Sage Handbook of the Philosophy of Social Sciences*, edited by I. C. Jarvie and J. Zamora Bonilla, 199-216. London: Sage.
- Bulle, Nathalie and Denis Phan. 2017. "Can Analytical Sociology Do without Methodological Individualism?", *Philosophy of the Social Sciences*, Online, First Published June 16, 2017.
- Bulle, Nathalie. 2018. "Methodological Individualism as Anti-reductionism", *Journal of Classical Sociology*, Online First.
- Bunge, Mario (2000), Systemism: the alternative to individualism and holism, *Journal of Socio-Economics* 29 (2000) 147–157
- Caldwell, B. 2007. *Hayek's Challenge: An Intellectual Biography of F. A. Hayek*. Chicago, IL: University of Chicago Press.
- Campagnolo, G. 2013. *Criticisms of classical political economy: Menger, Austrian economics and the German historical school*. London /New York: Routledge.
- Campanolo, Gilles (2016). The Identity of the Economic Agent — Seen From a Mengerian Point of View in a Philosophical and Historical context, *Cosmos +Taxis. Studies in Emergent Order and Organization*, double special issue, Vol. 3 / issues 2+3, pp. 54-77.
- Chen, S.-H. (2016). *Agent-based Computational Economics: How the Idea Originated and Where it is Going*. Routledge.
- Chen, S. H. (2016b). "The Missing Legacy of Herbert Simon in Agent-based Computational Economics", in *Decision Economics, In Commemoration of the Birth Centennial of Herbert A. Simon 1916-2016 (Nobel Prize in Economics 1978)* (pp. 1-7). Springer, Cham.

- Chen, S. H. and Y. F. Kao. (2016). *Herbert Simon and Agent-based Computational Economics*. In *Minds, Models and Milieux* (pp. 113-144). Palgrave Macmillan, London.
- Chen, S. H. (2005). "Computational Intelligence in Economics and Finance: Carrying on the Legacy of Herbert Simon". *Information Sciences*, 170 (1), 121-131.
- Chen, S.-H., and C. C. Ni (2000). "Simulating the ecology of oligopolistic competition with genetic algorithms". *Knowledge and Information Systems*, 2(3), 285-309.
- Coleman, James. 1990. *Foundations of Social Theory*. Cambridge, Massachusetts: Harvard University Press.
- Davis, J. B. (2013). "The Emergence of Agent-based Modeling in Economics: Individuals Come to Bits". *Filosofia de la Economia*, 1(2).
- Demeulenaere, Pierre, ed. 2011. *Analytical Sociology and Social Mechanisms*. Cambridge: Cambridge University Press.
- Di Iorio, Francesco. 2015. *Cognitive Autonomy and Methodological Individualism: The Interpretative Foundations of Social Life*. Berlin: Springer.
- Di Iorio, Francesco. 2016a. "Introduction: Methodological Individualism, Structural Constraints and Social Complexity." *Cosmos + Taxis: Studies in Emergent Order and Organization* 3 (2 & 3): 1-8.
- Di Iorio, Francesco. 2016b. "World 3 and Methodological Individualism in Popper's Thought." *Philosophy of the Social Sciences* 46 (4): 352-74.
- Di Iorio, Francesco and Catherine Herfeld. 2017. "Bookreview: *The Ant Trap* (Oxford University Press, 2015) by Brian Epstein", *Philosophy of the Social Sciences* onLineFirst, DOI:10.1177/0048393117724757, First Published August 31, 2017.
- Di Nuoscio, Enzo. 2016. "Herbert Spencer and Friedrich von Hayek: Two Parallel Theories." *Cosmos + Taxis: Studies in Emergent Order and Organization* 3 (2 & 3): 57-63.
- Di Nuoscio, Enzo. 2018. *The Logic of Explanation in the Social Sciences*. Oxford: Bardwell Press.
- Dupuy, Jean-Pierre, and Paul Dumouchel, eds. 1983. *L'Auto-Organisation de la Physique au Politique*. Paris: Seuil.
- Elster, J. 1985. *Making Sense of Marx*. Cambridge, UK: Cambridge University Press.
- Elster, J. 1989. *Nuts and Bolts for the Social Sciences*. Cambridge: Cambridge University Press.
- Epstein and Axtell (1996), *Growing Artificial Societies: Social Science from the Bottom Up*. Boston: Brookings Institution Press & MIT Press.

- Flache, Andreas, and Michael W. Macy. 2011. "Small Worlds and Cultural Polarization." *Journal of Mathematical Sociology* 35 (1): 146-76.
- Gräbner, Claudius and Kapeller, Jakob. 2015. "New Perspectives on Institutional Pattern Modeling: Systemism, Complexity, and Agent-Based Modeling", *Journal of Economic Issues*, Vol. XLIX No. 2 June 2015.
DOI 10.1080/00213624.2015.1042765
- Gräbner, Claudius (2016), "Agent-Based Computational Models - A Formal Heuristic for Institutional Pattern Modelling?" *Journal of Institutional Economics*, Vol. 12(1), 2016, p. 241-261.
- Hayek, Friedrich A. 1948. *Individualism and Economic Order*. Chicago: The University of Chicago Press.
- Hayek, Friedrich A. 1952. *The Counter-Revolution of Science: Studies on the Abuse of Reason*. Indianapolis: Liberty Press.
- Hayek, Friedrich A. 1967. *Studies in Philosophy, Politics and Economics*. Chicago: University of Chicago Press.
- Hayek, F.A. 1973. *Law, Legislation and Liberty, Vol. 1: Rules and Order*. Chicago, IL: University of Chicago Press.
- Hayek, F.A. 1978. *New Studies in Philosophy, Politics, Economics and the History of Ideas*. London: Routledge & Kegan Paul.
- Holland, J. H. and J. H. Miller. 1991. "Artificial Adaptive Agents in Economic Theory". *American Economic Review*, 81(2), 365-370.
- Holland, J.H. (1996), *Hidden Order: How Adaptation Builds Complexity*, Basic Books, New York.
- Izumi, K. and K. Ueda (2001). "Phase Transition in a Foreign Exchange Market-analysis Based on an Artificial Market Approach". *IEEE Transactions on Evolutionary Computation*, 5(5), 456-470.
- Jarvie, Ian C. 1972. *Concepts and Society*. London: Routledge.
- Jarvie, Ian C. 2001. *The Republic of Science: The Emergence of Popper's Social View of Science, 1935-1945*. Amsterdam: Rodopi.
- Kincaid, H. 1986. "Reduction, Explanation, and Individualism". *Philosophy of Science* 53(4):492-513.
- Kincaid, Harold. 1996. *Philosophical Foundations of the Social Sciences*. Cambridge: Cambridge University Press.
- Kincaid H. and Zahle J, H. (2019) "Why be a Methodological Individualist?" *Synthese*, 196(2), pp.655-675.
- King, A. 2004. *The Structure of Social Yheory*. London: Routledge.

- Kirzner, Israel M. 1978 *Competition and Entrepreneurship*. Chicago: University Of Chicago Press.
- Laurent, A. 1994. *L'individualisme méthodologique*, Paris: Puf.
- Lawson, T. (1997). *Economics and Reality*. London and New York: Routledge.
- Linares, F. 2018. "Agent Based Models and the Science of Unintended Consequences of Social Action". *Revista Española de Investigaciones Sociológicas*, 162 (<http://dx.doi.org/10.5477/cis/reis.162.21>), pp. 21-38.
- Lukes, S. 1968. "Methodological Individualism Reconsidered". *British Journal of Sociology*, 19:119–129.
- Lukes, S. 1973. *Individualism*. New York: Harper & Row.
- Macy, Michael W., and Andreas Flache. 2009. "Social Dynamics from the Bottom Up: Agent-Based Models of Social Interaction." In *The Oxford Handbook of Analytical Sociology*, edited by P. Hedström and P. Bearman, 245-68. Oxford: Oxford University Press.
- Mandelbaum, M. 1955. "Societal Facts". *British Journal of Sociology* 6(4) December: 305–317.
- Manzan, S., and F. H. Westerhoff. 2007. "Heterogeneous Expectations, Exchange Rate Dynamics and Predictability". *Journal of Economic Behavior & Organization*, 64 (1), 111-128.
- Manzo, Gianluca. 2013. "Educational Choices and Social Interaction: A Formal Model and a Computational Test". *Class and Stratification Analysis (Comparative Social Research)*, 30: 47-100.
- Manzo, Gianluca. 2014 "Data, Generative Models, and Mechanisms: More on the Principles of Analytical Sociology" in Manzo, G. (ed.). *Analytical Sociology: Actions and Networks*. Chichester: John Wiley.
- Marchionni, C. and P. Ylikoski. 2013. "Generative Explanation and Individualism in Agent-Based Simulation". *Philosophy of the Social Sciences*, online first 2 July 2013, DOI: 10.1177/0048393113488873.
- Menger, Carl. (1883) 1985. *Investigations into the Method of the Social Sciences with Special Reference to Economics*. New York: New York University Press.
- Mises, Ludwig von. (1922) 1981. *Socialism: An Economic and Sociological Analysis*. New York: Liberty Fund.
- Nadeau, Robert. 2016. "Cultural Evolution, Group Selection and Methodological Individualism: A Plea for Hayek." *Cosmos + Taxis: Studies in Emergent Order and Organization* 3 (2 & 3): 9-22.
- Nan N., Erik W. Johnston, and Judith S. Olson. 2008. "Unintended Consequences of Collocation: Using Agent-based Modeling to Untangle Effects

of Communication Delay and In-group Favor”. *Computational and Mathematical Organization Theory*, June 2008, Volume 14, Issue 2, pp. 57–83.

Neumann, Martin. 2008. “Homo Socionicus: A Case Study of Simulation Models of Norms.” *Journal of Artificial Societies and Social Simulation* 11 (4): Article No. 6. <http://jasss.soc.surrey.ac.uk/11/4/6.html>.

O’Driscoll, G.P. and M.J. Rizzo. 1995. *The Economics of Time and Ignorance*. Oxford/New York: Basil Blackwell.

Orcutt, G. H. 1957. “A New Type of Socio-economic System”. *The Review of Economics and Statistics*, 116-123.

Petitot, J. 2002. Vers des lumières hayekiennes: de la critique du rationalisme constructiviste à un nouveau rationalisme critique. In *Friedrich Hayek et la philosophie économique, Philosophie économique*, ed. Leroux A. and R. Nadeau. Colloque de Cerisy, No. 2.

Petitot, J. 2012. Individualisme méthodologique et évolution culturelle. In *Un austriaco in Italia. Studi in onore di Dario Antiseri*, ed. De Mucci. E. and K.R. Leube. Soveria Mannelli: Rubbettino.

Petitot, Jean. 2016. “Complex Methodological Individualism.” *Cosmos + Taxis: Studies in Emergent Order and Organization* 3 (2 & 3): 27-44.

Pettit, Philip. 1993. *The Common Mind: An Essay on Psychology, Society, and Politics*. Oxford: Oxford University Press.

Popper, Karl R. (1945a) 1966a. *The Open Society and Its Enemies, Vol. 1: The Spell of Plato*. Princeton: Princeton University Press.

Popper, Karl R. (1945b) 1966b. *The Open Society and Its Enemies, Vol. 2: Hegel and Marx*. Princeton: Princeton University Press.

Popper, Karl R. 1957. *The Poverty of Historicism*. Boston: Beacon Press.

Popper, Karl R. (1977) 2003. *The Self and Its Brain: An Argument for Interactionism*. London: Routledge.

Poteete, Amy R., Marco A. Janssen, and Elinor Ostrom. 2010. *Working Together: Collective Action, the Commons, and Multiple Methods in Practice*, Princeton: Princeton University Press.

Pribram, K. 2008. “La Genesi della Filosofia Sociale Individualistica.” In *L’individualismo nelle Scienze Sociali*, edited by E. Grillo. Soveria Mannelli: Rubbettino: 117-204.

Rainone, A. 1990. *Filosofia Analitica e Scienze Storico-Sociali*. Rome ETS.

Raub, Werber and Thomas Voss 2017. “Micro-Macro Models in Sociology: Antecedents of Coleman’s Diagram” in Ben Jann & Wojtek Przepiorka (eds.),

Social Dilemmas, Institutions and the Evolution of Cooperation. Festschrift for Andreas Diekmann, Berlin: De Gruyter.

Sawyer, R. Keith. 2002. "Nonreductive Individualism. Part I—Supervenience and Wild Disjunction." *Philosophy of the Social Sciences* 32 (4): 537-59.

Sawyer, R. Keith. 2003. "Nonreductive Individualism. Part II—Social Causation". *Philosophy of the Social Sciences* 33 (2): 203-24.

Sawyer, R. Keith. 2003. "Artificial Societies: Multi Agent Systems and the Micromacro Link in Sociological Theory." *Sociological Methods and Research* 31 (3): 325-63. Reprinted in *Computational Social Science*, edited by N. Gilbert, 2010. SAGE.

Sawyer, R.Keith. 2004. "The Mechanisms of Emergence." *Philosophy of the Social Sciences* 34 (2): 260-82.

Simon, H. A. (1962). "The Architecture of Complexity". *Proceedings of the American Philosophical Society*, 106: 467-482.

H. Spencer, *Specialised Administration* (1871), now in Id., *Essays: Scientific, Politic and Speculative* (1891), London, Routledge-Thoemmes Press, 1996, vol. III.

Squazzoni, F. (2009). *Epistemological Aspects of Computer Simulation in the Social Sciences*. Springer.

Squazzoni, F. (2014). "The Agent-Based Modeling Approach through Some Foundational Monographs". *Revue Française de Sociologie* 2014/4 (Vol. 55), pp. 827-840.

Tesfatsion, L. (2001). "Introduction to the Special Issue on Agent-based Computational Economics". *Journal of Economic Dynamics and Control*, 25(3), 281-293.

Tesfatsion, Leigh. 2017. "Modeling Economic Systems as Locally-Constructive Sequential Games". *Journal of Economic Methodology*, 24 (4): 384–409. doi:10.1080/1350178X.2017.1382068.

Trajkovski, G. and S. G. Collins (Eds.). (2009). *Handbook of Research on Agent-Based Societies: Social and Cultural Interactions: Social and Cultural Interactions*. IGI Global.

Udehn, L. 2001. *Methodological Individualism: Background, History and Meaning*. London/NewYork: Routledge.

Vriend, N. J. 2000. "An Illustration of the Essential Difference between Individual and Social Learning, and its Consequences for Computational Analyses". *Journal of Economic Dynamics and Control*, 24(1), 1-19.

Vriend, Nicolaas, J. 2002. "Was Hayek an Ace?" *Southern Economic Journal* 68, no. 4.

Watkins, J.W.N. 1955. Methodological Individualism: A Replay. *Philosophy of Science* 22(1), January: 58–62.

Watkins, J.W.N. 1957. Historical explanation in the social sciences. *The British Journal for the Philosophy of Science* 8(30) August: 104–117.

Weber, Max. 1946. *Essays in Sociology*. Oxford: Oxford University Press.

Weber, Max. 2005 (1953), *The Protestant Ethic and the Spirit of Capitalism*, Routledge: London and New York.