The Associations between Technologies and Societies: The Utility of Actor-Network Theory

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This article discusses the strengths and limitations of Actor-Network Theory (ANT) as a framework for Science and Technology Studies (STS). While ANT was originally rooted in Social Construction of Technology (SCOT) approaches, ANT has become a theoretical framework commonly used by scholars in numerous disciplines beyond STS, including Information Sciences. Although some scholars consider ANT to be now closer to sociomateriality studies, we claim that ANT differs from sociomateriality in that it suggests a different notion of power. In ANT, power results from actors' associations enacted into being rather than the sociomateriality claim that power results from existing power structures. We draw from our work on information technologies and social movements to illustrate this important distinction, and to show how ANT can be further strengthened by including the study of histories, memories and trajectories, in order to better understand power relations as associations enacted into being. In this way, we offer a deeper understanding of ANT and its utility for STS research in general, and information studies in particular.

Introduction

> The basic elements in Deleuzian thought are not static but entities in becoming. Consequently, the question to be asked is not what something is, but rather what it is turning into, or might be capable of turning into (Jensen & Rödje, 2010).

Actor-Network Theory (ANT) is a misnomer. ANT is, rather, a sociological approach, which focuses on the description and analysis of associations between natural, human and technological entities (Law, 2009). ANT informs Science and Technology Studies (STS) research with a method to trace associations between

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human and non-human agents in order to better understand how social dynamics are reassembled in contemporary settings, which are characterised as being more fluid, intricate and accelerated.

We suggest a trajectory that shows the historical and conceptual connections between ANT and the Social Construction of Technology (SCOT) approach, as well as with sociomateriality perspectives that emerged later. ANT offered one of the most notable transformations in the field of STS in the mid-1980s. It represented 'the turn to technology,' referring to the social shaping and the SCOT and technological systems (Jasanoff, Markle, Peterson & Pinch, 1995). However, during the 1990s, proponents of ANT distanced themselves from social constructivism and presented ANT as a more independent framework. With the turn of the century, other scholars started to consider ANT to be closer to other sociomateriality studies that include what Orlikowski calls 'entanglement in practice' (Orlikowski, 2010). Entanglement perspectives reject the notion that the world is composed of individuals and objects with separately attributable properties that 'exist in and of themselves.' Within entanglement perspectives, *sociomateriality* focuses on how meanings and materialities are enacted together in everyday practices (Barad, 2003, 2007; Introna, 2009; Suchman, 2007, 2009). However, we argue that even though ANT is part of the entanglement approaches, ANT differs from sociomateriality in that it suggests a different notion of power. While ANT expresses power as the result of actors' associations enacted into being, sociomateriality approaches tend to express power as the result of existing power structures.

Following Van House (2004), even though ANT has been criticised for its Machiavellian perspective of power as well as for its focus on the design and development of sociotechnical systems rather than their ongoing life, ANT represents a very useful alternative for STS research in order to better understand the interactions between social and technological phenomena, as well as the process of production of collective knowledge. Moreover, STS researchers can strengthen their analysis on the complex interactions between human and non-human agents that generate information and communication networks and systems, with the descriptive perspective of ANT focused on agents' practices and their associations, as well as with ANT theoretical and methodological principles that neither presume *the social* nor take for granted their power relationships and structures. In this sense, ANT is more appropriate for understanding sociotechnological interactions than the SCOT or sociomateriality approaches, or even Socio-Technical Interaction Network (STIN) methodology, which has been used for social informatics research. Early stages of SCOT (1984–1987), that Brey (2004) classifies as strong social constructivism, seem attached to an ontology of separateness[1] between humans and non-humans, which privileges humans' agency in social and technological interactions, and many of the sociomaterial analyses tend to neglect the specificity of the technological systems involved in the interactions between social and material worlds, and some of them have shown a lack of attention to deal with the broader contexts of practice and social structures (Mutch, 2013). Besides, STIN is more conservative than ANT in attributing agency to non-human agents and it

'is more prescriptive than SCOT and ANT, and focuses on patterns of routine use more frequently than patterns of adoption and innovation' Meyer (2006, p. 38).

During the last two decades, several studies that analyse the social and technological relationships between Information and Communication Technologies (ICT) and collective action have shown that ICT changed not only the ways in which activists communicate, collaborate and demonstrate but have also impacted political processes and civic engagement (Bimber, Flanagin & Stohl, 2009; Castells, 2007; Castells, 2009; Chadwick & Howard, 2009; Earl & Kimport, 2011; Juris, 2008). However, most research in this field has tended to omit or not clearly present the theoretical frameworks they are using to understand technologies, social movements, and the relationships between them. Such omissions and lack of clarity tend to produce more deterministic and simplistic perspectives on the roles and influence of ICT on social movements, and to obscure the degree of the ICT impacts on collective actions, and their influence in the broader political process.

Recent studies that tackle the interactions between ICT, particularly social media and social movements (Baron, 2013; Urribarri, 2015) have shown the need to use new lens to understand their entanglement, that not only helps identify emergent forms of sociotechnological phenomena (such us social movement networks), but also challenge the ways to understand and conceptualise the social movements themselves.

Using ANT perspective, our research (Baron, 2013) has shown that ICT, by themselves, have not transformed the social movement practices and collective actions. In other words, ICT alone have not produced revolutions or protests. However the entanglement between ICT and social movements has the potential (a) to transform and legitimise the ways social movements are producing and sharing information, (b) to help forge the narratives and collective identities and (c) to strengthen the expression and participation of youth as key agents in the performativity of social movements.

In order to better understand the utility of ANT, the article is organised as follows: the first part presents a trajectory of the theoretical and methodological stances of SCOT, ANT and sociomaterial approaches, as well as their connections. Then, it shows an analysis of some of the main strengths and limitations of each approach, and finally, the article provides some examples of the use of the specific form of ANT that we suggest here, taking into account some the author's research projects on ICT and social movements.

Social Constructivism: History, Structures and Human Agency

Social constructivism refers to a set of related, predominantly sociological approaches in science and technology studies. The roots of these studies lie in the combination of three distinct bodies of work: the empirical program of relativism, the sociology of scientific and technological knowledge and innovation in which ANT was first developed and the study of the social construction of technological artifacts (Bijker, 2010; Pinch & Bijker, 1984). In the mid-1980s, with many of them claiming that an integrated social constructivist approach towards the study

of science and technology was needed to understand both scientific facts and technological artifacts as social constructs (Pinch & Bijker, 1984).

The first studies of this approach advocated for an understanding of technology that comprises, first, artifacts and technical systems; second, the knowledge about these systems and, third, the practices of handling these artifacts and systems (MacKenzie & Wajcman, 1985). For Bijker (2010), constructivist studies of technology do not focus on the question 'What is technology?' Instead they trace the process of how to make technology. These studies mainly pointed to how technology is made and used, rather than what it essentially is.

Social constructivism studies employ a principle of *methodological symmetry* or *methodological relativism.* This implies that the analyst remains impartial as to the real properties of the objects of analysis. Among the most important concepts developed by this approach are *interpretative flexibility*, *the closure mechanism* and *the notion of social group* (Pinch & Bijker, 1984). Technology is claimed to have *interpretative flexibility*, meaning that technology has no objective or fixed properties but allows for different interpretations to its functional and socialcultural properties as well as its technical content. The *closure mechanism* refers to the stabilisation process of a technology, which includes both the rhetorical process of agreement on the nature of a technology, and the way in which technology functions in society. Hence, technology is socially constructed; its properties are largely if not exclusively determined by the interpretive frameworks and negotiation of *relevant social groups.* These groups are formed by the users and producers of the technological artifacts based on their shared or diverging interpretations of the technology in question (Brey, 2004).

The constructivist proponents do not necessarily constitute a homogeneous group. For Bjiker (2010), for example, 'social construction of technology' (or SCOT), when broadly used, encompasses both the Actor-Network approach (by Callon, Latour and Law during the 1980s), and the technological systems approach by Hughes. Used more narrowly, it refers primarily to the programme set out by Pinch and Bijker (1984). Brey (2004) also suggests a taxonomy of three broad approaches to classify the tendencies that converge within social constructivism: strong social constructivism, mid-social constructivism and ANT.

During the 1990s, as it is explained below, ANT scholars took a step back from social constructivism's main premises. This was the result of ANT explorations on the properties of actor networks, which triggered the need for new ontologies and sociologies, not only to better understand the associations between humans and non-humans, but also to develop more appropriate notions of networks and actors that correspond with a descriptive theory studying the deployment of networks (Latour, 1993, 1996; Law, 1991).

Recent Developments of Social Constructivism

During the 2000s, social constructivism had several shifts, including some produced by the discussions encouraged by ANT. More recently, Bijker (2010) discusses the development of the units of analysis in this approach, and he suggests three of them.

The first unit of analysis he identifies is the 'singular artifact' (technical system), where the artifact was used to represent the 'hardest possible case'. The second unit of analysis is the 'sociotechnical ensemble'. That is, the relations that play a role in the development of a technology are neither purely social nor purely technical; they are sociotechnical. The final unit of analysis he discusses is 'technological culture'. He affirms that technologies do not merely assist in everyday lives, but they are also powerful forces acting to reshape human activities and their meanings.

Even though social constructivist studies provide a viewpoint of sociotechnical relations, they still assume either that the social and the technological belong to different ontological stances, or they are agnostic with respect to the ontological status of technology and the natural world.

However Pinch has asserted that the job of the sociologist of technology is to try to recover the relationships between ontology and epistemology (Pinch, 2009, 2010). Moreover, a deeper consideration of certain properties of materiality is necessary for Pinch, if SCOT wishes to refine its ideas and simultaneously defend itself from critics (Pinch, 2009).

The next section presents the origins and goals of ANT as well as the main criteria that distanced it from social constructivism. Then the most important perspectives within ANT are described, including Latour's perspective that emphasises ANT contributions towards a sociology of associations, and Law's perspective that pays more attention to the tools of ANT and its own shifts.

ANT: Interactions, Mediations and Associations

ANT is not a theory according to Law (2009). It is a disparate family of material–semiotic tools, sensibilities and methods of analysis that treat everything in the social and natural worlds as a continuously generated effect of the webs of relations within they are located.

ANT maps associations that are simultaneously material and semiotic, and how material–semiotic networks come together to act as a whole; understanding that networks are potentially transient, existing in a constant making and remaking. For Latour (2007), there are three characteristics which identify ANT studies: one, the precise role granted to non-humans; two, the direction in which the explanation is going, the idea of social which they adopt and, three, whether the study aims at reassembling the social.

ANT's Origins and Goals

ANT was first developed by the Paris group of STS at the Centre de Sociologie de l'Innovation with the purpose of exploring the properties of actor networks since early 1980s (Latour, 1996). The term Actor-Network Theory, devised by Michel Callon, appeared in 1982, but the approach is itself a network that extends out in time and place. Law defines the 1990s as the period when an agenda, a vocabulary and a set of ambitions became current, a theory grounded in empirical case studies that tell stories about how relations assemble or not.

Table 1
Summary of Strengths of Social Constructivism, Actor-Network Theory and Sociomateriality

Social Constructivism	*Actor-Network Theory*	*Sociomateriality*
Introduces ways to think about and research the relationships between technology and society (non-deterministic models of technological change).	Understands that 'the social' also incorporates the natural and the material.	Digs on a relational ontology, which implicates epistemological and ethical shifts (situated practices of knowing in action, and a moral recognition of an entangled world of humans and non-humans).
Provides analytical and empirical tools to understand technology and society as culturally and historically embedded.	Stresses the relational character of technology and society under an analytical understanding of the ontological equivalence between humans and non-humans.	Leads to better understanding of performativity between material and social entities (challenging the power granted to language to determine what is real).
Recognises the role and *agency* of individuals, groups and institutions that develop technologies.	Points out that technology can also play a role as interactional *mediators* within human and non-human interactions.	Elaborates on *agency* and power as the result of situated practices in which different agents participate/ dispute with different material and discursive possibilities.

Source: Authors' own.

Against *the sociology of the social*, Latour suggests a *sociology of associations* in which the social refers to a movement of connections of human and non-human elements. Latour defines the social not as a special domain, a specific realm or a particular sort of thing, but as a very peculiar movement of re-association and reassembling. In addition, Law points out that while sociology is concerned with the whys of the social, ANT explores the how. ANT is a non-foundational perspective in which nothing is sacred and nothing is necessarily fixed (Law, 1991, 2009) (Table 1).

ANT Distances Itself from Social Constructivism

In mid-1990s, the scholars of ANT more clearly distanced themselves from the social-constructivism approach. In 1996, Latour reaffirmed that ANT did not limit itself to human individual actors but extends the word actor—or actant—to non-human, non-individual entities. From his perspective, a network notion implies a deeply different social theory: it has no a priori order relation. 'ANT is thus the claim that the only way to achieve this reinjection of the things into our understanding of the social fabrics is through a network-like ontology and social theory … an irreductionist and relationist ontology' (Latour, 1996, p. 370).

In conclusion, Latour shows that one of the big difficulties of grasping ANT is that it has been made by the fusion of three unrelated strands of preoccupations: 'a semiotic definition of entity building; a methodological framework to record the heterogeneity of such a building and an ontological claim on the "networky" character of actants themselves' (Latour, 1996, p. 373) (Table 2).

Table 2
Summary of the Limitations of Social Constructivism, Actor-Network theory and Sociomateriality

Social Constructivism	*Actor-Network Theory*	*Sociomateriality*
Persists in failing to achieve general claims and guidelines, which contradict its particular character and its case-study based emphasis.	Its analytical focus tends to omit the histories and trajectories of both humans and non-humans when they are interacting and developing different networks.	Shows difficulties to operationalise their premises and empirical findings.[6]
Tends to privilege humans' agency in social and technological interactions.	In spite of its analytical purposes, ANT tends to dismiss the structure, context and frameworks in which networks are entangled.	Several of these studies and analyses tend to neglect the specificity of the technological systems involved in the interactions between social and material worlds, and some of them have shown a lack of attention to deal with the broader contexts of practice and social structures (Mutch, 2013).

Source: Authors' own.

ANT's Main Trends: Latour and Law, Side by Side

Because ANT is considered by its proponents as a network, some of its more important advocates treat this approach in very particular ways and tell different stories about this framework. For example, Callon's (1986a–1986b) approach is focused on the mechanisms of power of science and technology, while Latour (2007) is more interested in a theoretical discussion with social sciences, in particular with sociology, and Law (2009) is more concerned with better understanding the characteristics of ANT's tools, sensibilities and methods of analysis. This article focuses on Latour and Law approaches taking into account that these two scholars are more concerned in presenting and defending a general perspective of ANT as a framework.

Latour (2007) offers a systematic exploration to use ANT for reassembling social connections. He suggests taking up three different duties in succession: first (*deployment*) shows how the annalists should not limit in advance the sort of beings populating the social; second, (*stabilisation*) shows how it is possible to render social connections traceable and third (*composition*) shows how to assemble the collective.

Law, on the other hand, pays more attention to the ingredients of ANT and its own shifts. His approach emphasises the following components: (a) the semiotic relationality, (b) the heterogeneity of actors, (c) the materiality of the social, (d) the space and scale and (e) the realm of performativity. Latour and Law's theories are presented side by side in what follows to demonstrate their key concepts and procedures, as well as to show some ways they are related.

ANT Introduces Uncertainties into Social Theory

Latour suggests departing, not from a closed set of a priori social constructions, but from the processes of formation of groups that always precede them. However the groups from the ANT do not represent any kind of social inertia. They must be constantly maintained, renovated or rebuilt, otherwise they cease to exist. Latour suggests a first uncertainty towards social theory, emphasising the need to explore the actors' agencies within a collective. The second uncertainty is related to the understanding of actors' actions. In ANT, an actor is what is made to act by many others; an actor 'is not the source of an action but the moving target of a vast array of entities swarming toward it' (Latour, 2007, p. 46).

The third uncertainty Latour introduces is that sociologists of associations should be ready to inquire about the agency of objects. In ANT, actants denote human and non-human actors that take shape in the networks that they do by virtue of their relations with one another. In ANT, the non-human elements can be agents—actants—because action is not necessarily intentional, and it is verified for its effects on other actors. The basic difference is that non-humans, thanks to the phenomenal expansion of technological devices and scientific facts in collective life, can no longer be considered neutral intermediaries but must be understood as mediators, often silent, which modify the relationship among other agents (Latour, 2007).

Heterogeneity of Actors and Mediations in ANT

For Law (2009), the existence of different kinds of actors is an expression of *heterogeneity*, and the recognition that 'stuff is there aplenty, not just "the social"'. It is also evidence of the *materiality* within networks and the relations between humans and non-humans that play their part moment by moment, relationally. He also explains how the actors define and shape one another in a network where the elements, people or objects, are subordinate to the logic of the architecture, created or reshaped in that system. Law describes *semiotic relationality* as a network whose elements define and shape one another.

Latour describes human and non-human relations in terms of various forms of mediation. And the *stability* of those mediations produces/maintains certain durability in social interactions (Latour, 2009). However, with his fourth uncertainty, he advises that the agencies, and the associations they produce, should never be presented simply as matters of fact but always as matters of concern, with their mode of fabrication and their stabilising mechanism clearly visible.

Mediation is an important concept when ANT analyses the associations between humans and non-human agents. Mediators, which are to be understood as different from intermediaries, are entities that transform and multiply differences during the interactions among these agents. Their outputs cannot be predicted by their inputs. The notion of mediation is a sort of 'cooperative' work between different 'actants',[2] and implies that non-humans can develop mediations and can produce different assemblages, actions and effects. It also implies that different artifacts

and technologies can develop diverse forms of mediation which can transform, translate, distort or modify meanings or elements (Latour, 2007, 2009).

Tracing Associations and Rendering Stabilisation with ANT

The aim of the sociology of associations is a *network-tracing* activity. For Latour (1996), ANT is not about *traced* networks, but about the activity of network *tracing*, because a network cannot exist independently of the act of tracing it (Tatnall, 2012). In this way, ANT responds in the only non-foundational way it can: by exploring the logic of different networks' architecture, and looking for configurations that might lead to relative stability (Law, 2009). Network is a concept for ANT, 'not a thing out there'. 'It is a tool to help describe something, not what is being described …' (Latour, 2007, p. 131).

From an ANT perspective, after tracing networks, the social scientist has to grant the actors the ability to make up their own theories about what the social is made of. Within a network, this sociology of associations looks for the new institutions, procedures and concepts able to collect and reconnect the social. In this sense, the notions of *power* or *scale*, instead of being predefined characteristics of a field or an area, are functions of a network's configuration.

According to Law, the current challenges of ANT are related to the notion of *performativity*. This implies that entities are not *real* until they are *enacted into being*. He maintains that a vital metaphorical and explanatory shift is taking place: 'We are no longer dealing with *construction*, social or otherwise: there is no stable prime mover, social or individual, to construct anything, no builder, no puppeteer … Rather we are dealing with *enactment* or *performance*. The metaphor of construction—and social construction—will no longer serve' (Law, 2009, p. 151). For Law, this implies an understanding that each practice generates its own material realities, and they are temporal and are enacted differently in different places.

The next section presents the main characteristics of the entanglement approach the way ANT dialogue and nourishes sociomaterial perspectives.

The Entanglements in Practice

In an extensive literature review, Orlikowski (2010) shows that a group of scholars has been working within a *relational ontology*, which rejects the notion that the world is composed of individuals and objects with separately attributable properties. Such ontology privileges neither humans nor technologies, nor does it treat them as separate and distinct entities. Orlikowski characterises these new studies with the label 'entanglement in practice' (Orlikowski, 2010, p. 135).

In particular, Orlikowski shows that one influential example of an entanglement perspective is ANT. She highlights that entities acquire their form and attributes from ANT only through their relations with others; there are no separate social or technological elements that might shape, or be shaped by each other. She also shows that meanings and materialities are enacted together in everyday practices,

because technologies are bound up with the specific material-discursive practices that constitute certain phenomena (Alam & Brooks, 2013; Barad, 2003; Barad, 2007; Introna, 2009; Suchman, 2007, 2009).

In what follows, some of the most important reflections and findings of the first stream of sociomateriality accounts are presented, while some of the core premises of ANT are discussed.

Sociomaterial Accounts that Dialogue with and Challenge ANT

Sociomaterial accounts share significant theoretical analyses and methodological practices with post-structural and post-colonial theories that focus on social and material aspects with equal importance, including feminist theory, complexity theory and work systems theory. During the 1980s, the emergence of the feminist perspective of technology nurtured STS, not only insisting that technology was the product of social relations, but they also pointed out that there were other powerful forces shaping technology, such as militarism, capitalist profitability, racism and the structure of gender relations (Wajcman, 1995).

More recently, feminist theorists such as Suchman (2007) have maintained that feminist scholars have embraced the inseparability of subjects and objects. In particular, she points out that studies of this approach have added crucial sensibilities to the reconceptions of *agency* under development in STS, such as favouring particular and specifically situated practices of knowing in action; directs attention to sociotechnical assemblages and the capacities for action that they enable and orienting us not only to relations and symmetries among persons and things, but also to the politics of difference.

In another vein, Introna points out that our existence has become so entangled with the things surrounding us 'that it is no longer possible to say, in any definitive way, where we end and they begin, and vice versa' (Introna, 2009, p. 26). Moreover, based on Latour's reflections, Introna asserts that technology, like morality, is not simply a matter of our choosing, which not only represents a deep critique into the anthropocentric idea of agency and ethics, but also disturbs 'the categories of freedom, autonomy and responsibility at the heart of the liberal ethical project' (Introna, 2009, p. 29).

Barad (2003) developed a relational ontology that she calls *agential realist ontology*, that takes Niels Bohr's post-Newtonian framework based on 'quantum wholeness' or inseparability, which understands there is not an inherent distinction between the 'observed object' and 'agencies of observation.' Barad (2003; 2007) also proposes a *post-humanist materialist* framework of performativity that suggests a rethinking of the notions of material phenomena and discursive practices, and the relationship between them. Thus the performativity approach challenges the representationalist belief in the power of words to represent pre-existing things. For Barad, matter is not a fixed essence; rather, matter is substance in its intra-active becoming, not a thing but a doing (Barad, 2003).

Barad's sociomaterial framework also implies a notion of *agency*. She understands it as a matter of intra-acting; it is an enactment, not something that someone

or something has. Agency 'cannot be designated as an attribute of subjects or objects (as they do not preexist as such)' (Barad, 2007, p. 214).

Towards Complex and Mobile theories of Technology and Society

According to the characterisations on social constructivism, ANT and sociomateriality provided above, these frameworks show distinct intersections and divergences among them. Social constructivism and ANT approaches are historically and conceptually connected, as has been shown already. Something similar happens between ANT and current sociomaterial convergences. The three approaches also present strengths and limitations that are worth pointing out (see Table 1 & 2).

Contributions of ANT

Having outlined some of ANT's strengths and weaknesses, four main ANT concepts emerge, which help to better investigate and analyse social interactions with technology:

1. that human and non-human associations are enacted in practice;
2. that 'following the actors' helps to better understand the social as a 'movement of re-association and reassembling';
3. that material conditions matter and non-human elements can be agents that come to existence in associations with other human and non-human agents and
4. that non-humans mediate human and non-human interactions.

Relationality and Association

Coming from different theoretical and disciplinary fields, the more active and visible advocates of ANT, Michel Callon, Bruno Latour and John Law, have positioned a non-foundational perspective on multiple associations between different entities which make it possible to trace and explain. The notion of association, indeed, suggests an alternative rationality founded on interactions, flows, change and movement. All of them are important characteristics in the task of tracing associations within social movement networks.

Following the Actors

ANT has an underlying method in which sociologists participate, and 'follow the actors'. This method is based upon three subsequent phases: deployment, stabilisation and composition. After this, ANT proposes to trace networks as well as to detect *stabilisation* mechanisms during certain moments of those networks' interactions. Then ANT recommends going back to the agents and letting them speak about those stabilisation moments in order 'to grant them

back the ability to make up their own theories of what the social is made' (Latour, 2007, p. 11).

Just after each of these actions, the sociologist of the social attempts to register both the novelty of associations and the stabilisation mechanisms in a comprehensible form. Thus, the composition task (this is the creation of explanations), implicates a work between the networks' participants and the sociologists of the social, which should be open for public scrutiny as well. In this sense, to study is always to do politics, because it collects or composes what the world is made of.

Materiality

Scholars from both social constructivism and sociomateriality have pointed out that one of the most challenging contributions of ANT is related to the agency of non-humans and their interactions with humans. The idea that 'reality' is a result of the interactions of heterogeneous social, technical and textual materials has generated several ontological discussions, and an ontological change with repercussions for epistemological approaches. These shifts expand our ideas around relational ontologies and equip us to understand better the levels at which contemporary existence is entangled with technological entities. Furthermore, the shifts confront our theoretical and methodological assumptions, and force us to question materiality, infrastructure and 'stuff'. Among the three approaches, ANT is the only one that yields insights into some crucial aspects of the material, including the physical characteristics and capabilities entailed in other technological objects (Mutch, 2013; Orlikowski, 2010).

Mediations

Mediation has been shown to relate to the concept of association. The explanation that different artifacts and technologies can develop diverse forms of mediation is strong, mainly because mediation implies transformation, translation, distortion and modification of meanings or elements. These ideas resonate well with significant shifts in communication and information approaches in Latin America that, since late 1980s, have sustained the mediation character of mass media as part of social dynamics and movements that have transformed not only the social, but also the political and cultural (Martín B, 1993).

It is important to take into account that ANT recognises non-human mediations (this is the agency attribute of non-humans) but not intentionality. Attributing causal agency to objects represents a technical determinism that ANT rejects (Latour, 2007).[3]

Limitations of ANT

Despite these four contributions, there are at least three major limitations that result from choosing ANT to guide research on social interactions with technology:

1. The role of histories, memories and trajectories.
2. Actants are not equal.
3. Body and embodiment.

Histories, Memories and Trajectories

According to ANT, the social is a result of multiple and dynamic associations among different kinds of entities. This performing nature of the social suggests an analytical emphasis on entities' association while they are in action. However, it also suggests some lack of attention to issues of the history, memory and trajectory of those entities, and the effect that the entities' histories, trajectories and memories could have in their actions and associations. Without adopting a foundational perspective, in this research it is suggested that entities' histories, memories and trajectories play a part in the process of their actions and associations, which are also revitalised and transformed in action and in association. That is, histories, memories or trajectories also mediate the process of associations when *they are enacted into being*.

Non-foundational and dynamic studies on these aspects we just referred to, could enrich the task of tracing and explaining associations. In particular, interdisciplinary works such as Ricoeur's (2004) studies on the relationships between remembering and forgetting and their connections with the perceptions of historical experiences and the production of historical narratives; or Sarlo's (2005) discussions and critiques of the contemporary emphasis on personal testimonies and memoirs; or Sontag's (2003) investigations on the role of information and imagery in contemporary culture, can shed light on this research. These approaches not only underlined the performance and interactional character of memories and histories, as relational and dialogical processes connected with sociotechnical and cultural representations and actions, but they also support the need to develop more appropriate intellectual tools to better grasp and understand those relationships.

Actors Are Not Equal

In the same vein as the previous argument, ANT focuses on agents' actions and associations, and this could obscure the role that some 'structural' conditions can have on agents' performances and networks' functions. The actants' attributes and their positions within a network, and the power they get, can also affect the forms and patterns of associations that the agents develop in practice. As Suchman (2007, 2009) and Barad (2007) assert, agency is always inextricably tied to the specific sociomaterial arrangements of which it is a part, and it is the result of particular practices that implicate possibilities and boundaries.

Additionally, Van House (2004) points out that ANT, as well as the social constructivism approach, have both been criticised 'for being overly focused on the heroic design/invention stages and the groups involved at that point, ignoring users and operators and the ways that technology is appropriated by users' (Van House, 2010, p. 20).

For tracing and mapping networks, the dynamic and changing positions, capabilities and conditions of actants could be considered (including users, operators and agents who are not the main actors of sociotechnical controversies). Bourdieu's theory on cultural fields provides an alternative to complement ANT in this aspect, without competing with it. Bourdieu suggests an analytical method that includes the definition of fields of studies; the identification of actors within the fields; the description of actors' roles and positions within the fields and the actors' accumulation and use of different forms of material and symbolic power that this author mainly characterised as capital. Bourdieu made a significant contribution to the analysis between cultural practices and broader social processes, in which symbolic aspects of social life are inseparably intertwined with the material conditions of existence. In an attempt to transcend this dichotomy, Bourdieu's approach 'sought to develop a concept of agent free from the voluntarism and idealism of subjectivist accounts and a concept of social space free from the deterministic and mechanistic causality inherent in many objectivist approaches' (Bourdieu & Johnson, 1993, p. 4).

Body and Embodiment

Even though ANT has developed an important guide that recognises the importance of materiality, it lacks a deep analysis of the 'bodies' and processes of embodiment' within networks. These include a reflection on both human and non-human bodies. The presence of bodies and the process of embodiment represent immense challenges not only for ANT studies, but also for other sociotechnical analysis of networks and organisations. Bodies and embodiment also point out a significant challenge in the studies on communication and information processes that are part of networks and organisations. Sociomaterial studies have developed extensive analyses and discussions on bodies and embodiment (e.g. Barad, 2007; Butler, 1993; Suchman, 2007) that could offer an important contribution for the analyses of contemporary social movements and the ways they have integrated different technologies.

Positioning Social Research in Relation to ANT: The Study of ICT and Social Movements' Interactions

ANT proposes a shift for understanding relations between technologies, individuals and collectives in deep and complex forms. It implies a relational ontology that is appropriate to better understand the entanglement between ICT and social movements, especially in contemporary dynamics, which are characterised as being more fluid, intricate and accelerated.

Our research project adopted the interactional rationality and the associations between human and non-humans agents. For this reason, the social movements are understood here as intricate associations of individual and collective agents (humans and non-humans) that are neither homogeneous, nor definitive. Thus, a

new conceptualisation of social movements is suggested as complex networks of individual and collective agents (both humans and non-human), which constitute waves of confrontational social engagement at many levels and encompass different forms of performances and associations marked by their oppositional but proactive character. Thus, the departure point of our research is neither from technologies nor human actors, nor demarcated social fields.

In order to follow the actors, as suggested by ANT, our study utilised a multi-sited ethnography. This is a method of data collection developed by Marcus (1995) to examine transnational dynamics and the increasing interconnectedness processes of globalisation. This approach is concerned with the adaptation of longstanding modes of ethnographic practices to more complex objects of study. These practices move from conventional, single-site locations, contextualised by macro-constructions of a larger social order, to multiple sites of observation and participation. Multi-sited ethnography provides a framework to analytically trace populations, ideas and material objects through time and space. This method helps us to follow different contemporary collectives (such as social movements) which are related to transnational dynamics (such as social movements that links local and international actions); interconnected social spaces and times (offline and online); as well as practices, symbols and technologies (such as social mobilisation, stories and social media).

ANT moves toward *performativity*, in which matters of practices/doings/actions are central, and fit very well with projects focussed on social movement practices, where silent and non-evident actions and mediations of technologies are decisive. Our research project borrows Melucci's ideas (1994, 1995, 1996) about the symbolic and communicative character of social movements, and the importance that he attributes to information and technologies, which have become crucial resources for contemporary complex systems, as terrains where new forms of power, discrimination and conflict come into being (Melucci, 1994, 1996). In this sense, he suggests analysing the relationships among the performances, the identities and the communication and information practices within social movement networks.

Material characteristics and trajectories of technology, such as social media, are traced, described and analysed in our approach. However, those characteristics are contrasted with the technological, sociopolitical and cultural contexts where technologies are embedded. Our analysis also observes different roles and power relationships that agents (non-human and human) develop within different networks formations in different contexts (Baron, 2012).

Our studies point out that ICT, particularly social media, by themselves, has not transformed the social movement practices and collective actions. However, platforms such as Facebook has had an active role within the social movement interactions, which shows (a) a potential to transform and legitimise their ways of producing and sharing information, *the legitimation cycle of information*; (b) a potential to help forge the narratives and collective identities of social movements' participants, *a liminal scenario for voice-building* and (c) a potential to strengthen the expression and participation of youth as key agents in the

performativity of social movements, *a social space for youth expression and sociopolitical participation*.

We found that Facebook has enabled three types of mediations in the interactions between social movements' participants that enhance their relations and their actions:

1. *A legitimation cycle of information*: through Facebook, the social movements' participants developed an alternative space where information was not only produced and circulated collectively, but where information was discussed and validated collectively. Storytelling was the main form in which information was shared. This information generated awareness and identity, as well as motivating action among social movements' participants and their networks. Information 'legitimised' through Facebook interactions became a currency or capital[4] that social movements' participants could transform and exchange in other sociopolitical arenas. The information cycles legitimised through Facebook opened new individual and collective opportunities for social movements to interact with key stakeholders, such as communities, elected officials and mass media, while empowering the social movements' during these interactions.
2. *A liminal scenario for voice-building and shaping of identities*: through Facebook, the social movements' participants have created a liminal scenario, a threshold that provides them with a space or place of transition for building a voice of their own and shaping their identities. Three components are crucial for building their voices and identities in the liminal scenario afforded by ICT such as Facebook: (a) branding who they were and what they did; (b) preserving their memories through storytelling and (c) making their networks and connectedness visible. The liminal scenario allowed the social movements' participants to position their voices and to develop more autonomous narratives, which are mainly created and controlled by social movements' participants.
3. *A social space for youth expression and sociopolitical participation*: youth participating in the social movements have used Facebook as an alternative space and as a language to create and share stories about themselves and their social and political activities in a familiar, non-threatening platform. This helped youth position their voices and participation in social organisations and larger social movements. Facebook in the hands of multicultural youth enabled them to develop new languages and codes, and to become better 'cultural translators'[5] between key stakeholders in different social spaces. The new voices, stories and forms of participation from youth using Facebook re-energised and transformed the social movements' practices and strategies and contributed to revitalising their actions and performance.

With the evidence of our studies, we claim that the associations of human and non-human agents of the social movements, especially younger participants, and Facebook, are changing the information and communication practices in those movements, as well as their interactions with other social and technological agents (e.g., elected officials or communities, and email, texting or Twitter). However, these associations also have the potential to transform their collective identities and performativity, and their interactions with other agents such as authorities, mass media and social movement networks. In this sense, the associations of human and non-human agents have the potential to transform social movements, and to transform our understanding of those social movements in action.

Thus, ANT provides a framework which (a) focuses on the formation process of collective action as a result of complex, moving and continuously generated associations (webs) that integrate humans and technologies; (b) combines the analysis of symbolic, practical and technological dimensions of human and technological associations and (c) emphasises the analyses of *social practices.* The social in ANT also incorporates the natural and the material. Moreover, ANT suggests an approach that explores the active role (the agency) not only of the human components of networks, but also of their technological entities. In this sense, technologies can mediate human and technological interactions. Furthermore, ANT offers an understanding of power that results from actors' associations 'enacted into being', which is a departure from the more simplistic approaches of sociomateriality, in which power is seen solely as the result of existing power structures. As we have seen, power can be enacted at the very least through three mechanisms legitimation of information, building and shaping of identities and establishment of social spaces for youth expression and participation, all of which can result in changing practices and interactions between social actors and technical platforms they use to enact their emerging power.

ANT also has limitations, as we have discussed. We suggest that historical and contextual accounts on human and non-human agents need to be incorporated to better explain the agents' trajectories and their agencies within different networks. These additions also point towards richer frameworks for researching how different kinds of information and communication technologies are entangled in particular sociopolitical circumstances in which social movements navigate regularly.

The point of departure for the approach suggested here assumes an interactional perspective, which emphasises human and non-human practices that are not static but are entities in becoming, as Jensen & Rödje might say, paraphrasing Deleuze. ANT offers a solid ground to describe and analyse the ongoing associations of social groupings and their uses of technology in their multiplicity, flow and temporality, rooted in an understanding of power as the result of associations that are enacted through interaction. Thus ANT provides an alternative to better understand how society and technology have become entangled, and ways to understand such entanglement in STS.

NOTES

1. Orlikowski uses this term to refer to the approaches that assume that technology and humans are essentially different and separate realities (Orlikowski, 2010).
2. Latour uses the technical word *actant* that comes from the study of literature, especially from Algirdas Julien Greimas, who developed the actantial model of semiotic analysis of narratives. . . See more at (Latour, 2007, p. 54).
3. See more on the differences on agency and intentionality, as well as on intermediaries and mediators, at (Diaz Andrade, 2012).
4. In Bourdieu and Johnson's perspective, capital is an actor's accumulation and uses of different forms of material and symbolic powers (Bourdieu & Johnson, 1993).
5. In ANT, 'translation' is an important concept that refers to a relation that induces two mediators into coexisting. (For Latour, the aim of the sociology of associations (ANT) is to show that 'there exist translations between mediators that may generate traceable associations' (Latour, 2007, p. 108).
6. This is probably due to the variety of approaches that these studies cover, many of them dealing with philosophical questions and frameworks.

REFERENCES

Alam, M. S., & Brooks, L. (2013). *Constitutive entanglement: Infomediaries and intermediaries in land records in Bangladesh*. Paper presented at the 12th International Conference on Social Implications of Computers in Developing Countries, Ocho Rios.

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs, 28*(3), 801–831.

Barad, K. M. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. United States of America: Duke University Press.

Baron, L. F. (2012). More than a Facebook revolution: Social movements and social media in the egyptian arab spring [Special Issue December 2012]. *International Review of Information Ethics, 18*(12), 13.

———. (2013). *The power of associations. Social media and social movements: Facebook in the interactions of social movement organizations* (Doctor of Philosophy). University of Washington. Retrieved from https://digital.lib.washington.edu/researchworks/handle/1773/25133

Bimber, B., Flanagin, A. J., & Stohl, C. (2005). Reconceptualizing collective action in the contemporary media environment. *Communication Theory, 15*(4), 365–388.

Bijker, W. E. (2010). How is technology made?—That is the question! *Cambridge Journal of Economics, 34*(1), 63–76.

Bourdieu, P., & Johnson, R. (1993). *The field of cultural production: Essays on art and literature*. New York: Columbia University Press.

Brey, P. (2004). Philosophy of technology meets social constructivism: A shopper's guide. In D. M. Kaplan (Ed.), *Readings in the philosophy of technology* (pp. 98–111). Lanham, MD: Rowman & Littlefield Publishers.

Butler, J. (1993). *Bodies that matter: On the discursive limits of 'sex'*. New York: Routledge.

Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and the fisherman. In J. Law (Ed.), *Power, action and belief* (pp. 196–223). London: Routledge & Kegan Paul.

———. (1986). The sociology of an actor-network: The case of the electric vehicle. In M. Callon, J. Law & A. Rip (Ed.), *Mapping the dynamics of science and technology: Sociology of Science in the Real World* (pp. 19–34). Hong Kong: The Macmillan Press.

Callon, M. (1987). *Society in the making: The study of technology as a tool for sociological analysis.* Paper presented at the The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology, Cambridge, MA.

Castells, M. (2007). Communication, power, and counter-power in the network society. *International Journal of Communication, 1*, 238–266.

Castells, M. (2009). *Communication power*. Oxford & New York: Oxford University Press.
Chadwick, A., & Howard, P. N. (2009). *Routledge handbook of Internet politics*. London, New York: Routledge.
Diaz Andrade, A. (2012). From intermediary to mediator and vice versa: On agency and Intentionality of a mundane sociotechnical system. In A. Tatnall (Ed.), *Social influences on information and communication technology innovations* (pp. 195–204). Hershey, PA: Information Science Reference.
Earl, J., & Kimport, K. (2011). *Digitally enabled social change: Activism in the Internet age*. Cambridge, MA: MIT Press.
Introna, L. D. (2009). Ethics and the speaking of things. *TCS Theory, Culture & Society, 26*(4), 25–46.
Jasanoff, S., Markle, G., Petersen, J., & Pinch, T. (1995). *Handbook of science and technology studies*. Thousand Oaks, CA: SAGE Publications.
Jensen, C. B., & Rödje, K. (2010). *Deleuzian intersections: Science, technology, anthropology*. New York: Berghahn Books.
Juris, J. (2008). *Networking futures: The movements against corporate globalization*. Durham, NC: Duke University Press.
Latour, B. (1993). *We have never been modern*. Cambridge, MA: Harvard University Press.
———. (1996). On actor-network theory. A few clarifications. *Soziale Welt, 47*(4), 369–381.
———. (2007). *Reassembling the social: An introduction to actor-network-theory*. Oxford & New York: Oxford University Press.
———. (2009). A collective of humans and nonhumans: Following Daedalus's labyrinth. In D. M. Kaplan (Ed.), *Readings in the philosophy of technology* (p. 11). Lanham: Rowman & Littlefield Publishers.
Law, J. (1991). *A Sociology of monsters: Essays on power, technology, and domination*. London & New York: Routledge.
———. (2009). Actor network theory and material semiotics. In B. Turner (Ed.), *The New blackwell companion to social theory*. Chichester: John Wiley & Sons.
MacKenzie, D. A., & Wajcman, J. (1985). *The social shaping of technology: How the refrigerator got its hum*. Milton Keynes & Philadelphia: Open University Press.
Marcus, G. E. (1995). Ethnography in/of the world system: the emergence of multi-sited ethnography. *Annu Rev Anthropol Annual Review of Anthropology*, *24*, 95–117.
Martín B. J. (1993). *Communication, culture and hegemony: From the media to mediations*. London & Newbury Park: SAGE Publications.
Melucci, A. (1994). A Strange kind of newness: What's New in New Social Movements? In E. Laraña, H. Johnston & J. R. Gusfield (Eds), *New social movements: from ideology to identity*. Philadelphia: Temple University Press.
———. (1995). The process of collective identity. In H. Johnston & B. Klandermans (Eds), *Social movements and culture*. Minneapolis, Minn.: University of Minnesota Press.
———. (1996). *The playing self: person and meaning in the planetary society*. Cambridge; New York: Cambridge University Press.
Meyer, E. T. (2006). Socio-technical interactions networks: A discussion of the strengths, weaknesses and future of Kling's STIN model. In J. Berleur, M.I Numinen, J. Impagliazzo (Eds), IFIP international federation for information processing, 223, *Social informatics: An information society for all? In remembrance of Rob Kling* (pp. 37–48). Boston: Springer.
Mutch, A. (2013). Sociomateriality taking the wrong turning? *INFORG Information and Organization, 23*(1), 28–40.
Orlikowski, W. J. (2010). The sociomateriality of organisational life: Considering technology in management research. *Cambridge Journal of Economics, 34*(1), 125–141.
Pinch, T. (2009). The social construction of technology (SCOT): The old, the new, and the nonhuman. In P. Vannini (Ed.), *Material culture and technology in everyday life: Ethnographic approaches* (pp. 45–58). New York: Peter Lang.
———. (2010). On making infrastructure visible: Putting the non-humans to rights. *Cambridge Journal of Economics, 34*(1), 77–89.

Pinch, T. J., & Bijker, W. E. (1984). The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science, 14*(3), 399–441.

Ricoeur, P. (2004). *Memory, history, forgetting*. Chicago: University of Chicago Press.

Sarlo, B. (2005). *Tiempo pasado: Cultura de la memoria y giro subjetivo: una discusión [Past Time: memory culture and the subjective turn: a discussion]*. Buenos Aires: Siglo Veintiuno Editores Argentina.

Sontag, S. (2003). *Regarding the pain of others*. New York: Farrar, Straus and Giroux.

Suchman, L. (2007). Agencies in technology design: Feminist reconfigurations. Proceedings of the 5th European Symposium on Gender & ICT Digital Cultures: Participation - Empowerment – Diversity March 5 - 7, 2009 - University of Bremen.

Suchman, L. (2009). *Human-machine reconfigurations: Plans and situated actions*. Cambridge: Cambridge University Press.

Tatnall, A. (2012). *Social influences on information and communication technology innovations*. Hershey, PA: IGI Global.

Urribarri, R. (2015). Comunicación y democracia en el siglo XXI: El reto de la formación. *ChasquiNet, Revista Latinoamericana de Comunicación [*Communication and democracy in the XXI Century: the education challenge. *ChasquiNet*, Latin American Journal on Communication*], No. 128.*

Van House, N. (2004). Science and tecnology studies and information studies. *Annual Review of Information Science and Technology, 38*(1), 1–86.

Wajcman, J. (1995). Feminist theory of technology. In S. Jasanoff, G. Markle, J. Petersen & T. Pinch (Eds), *Handbook of science and technology studies* (pp. 189–204). Thousand Oaks, CA: SAGE Publications.