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## Successful Interdisciplinary Collaborations: The Contributions of Shared Socio-Emotional-Cognitive Platforms to Interdisciplinary Synthesis

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Successful Interdisciplinary Collaborations:  
The contributions of shared socio-emotional-cognitive platforms to  
interdisciplinary synthesis<sup>1</sup>

Veronica Boix Mansilla,  
Michèle Lamont and  
Kyoko Sato  
Harvard University

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## ABSTRACT

Available theories concerning interdisciplinary collaborations tend to focus on either the cognitive or the social dimension of such interchange. We propose the theoretical construct of “*shared socio-emotional-cognitive (SSEC) platforms*” to capture what defines successful interdisciplinarity. The paper elaborates on this theoretical concept, which is informed by an extensive empirical study of nine research networks supported by three institutions: the Canadian Institute for Advanced Research, the MacArthur Foundation, and the Santa Fe Institute. We also analyze the conditions that enable or impede individuals to conduct interdisciplinary research together successfully, focusing on intellectual, interactional and institutional conditions. We first review relevant literature on interdisciplinary collaborations, and then advance a definition of *SSEC platforms*, describing three key dimensions and the theoretical assumptions on which they stand. These dimensions are: the cognitive-intellectual (most exclusively concerned with substance); the emotional (concerned with reactions to individuals and ideas); and the socio-interactional (concerned primarily with interaction, meaning-making, and group styles). These dimensions are also described as conditions enabling successful interdisciplinarity. They operate together with institutional conditions for success, which concern the rules, practices and expectations of funding organizations and the academic fields. After showing that these dimensions and conditions are present in the nine groups studied, but in varying proportions, we conclude by comparing our construct with the notion of “trading zones” (Galison 1997) to specify our constructs’ usefulness and contribution to the field.

"To be a Shakespearean scholar, absorb oneself in black holes or attempt to measure the effects of schooling on economic achievement--is not just to task up a technical task but to place oneself inside a cultural frame that defines and even determines a very great part of one's life"

Clifford Geertz *Local Knowledge* 1983

## Introduction

Research is becoming increasingly interdisciplinary (Brint 2009; Bruce et al 2004; EURAB 2004; National Academies 2005). Phenomena ranging from the earth's climate to stem cells, from population genetics to the human brain have raised the need to integrate knowledge, and militate against long-standing academic trends toward specialization and knowledge fragmentation. Indeed, the most pressing challenges of cultural and environmental survival today require integrative approaches (Boix Mansilla 2009). Interdisciplinarity has become synonymous with creativity, progress, and innovation (Bruun & Toppinen 2004; Huutoniemi et al 2008).

Responding to these new forms of knowledge production (Gibbons et al 1994), a growing number of initiatives point to the need for – and difficulties of – cross-disciplinary dialogue. Since 2000, academic strategic plans and federal funding agencies across the United States have committed to interdisciplinary research and graduate training (Brunn et al 2005a 2005b; Feller 2002, 2006; NSF 2006, MIT 2010). They are nurturing cross-disciplinary exchange, but are also meeting the problem of framing, monitoring, supporting, and assessing, quality in interdisciplinary work (Boix Mansilla 2006 a b, Feller 2002; Lamont, 2006, 2007; Laudel 2006).

The success of an interdisciplinary group pivots on its capacity to amalgamate disciplinary perspectives to leverage understanding. Interdisciplinary synthesis can unfold in an individual researcher's mind. Yet much contemporary research takes place through "distributed cognition" (Hutchins 1995), involving several specialists capable of melding theories, methods, and data from different disciplines (Derry et al 2005). What constitute "successful" interdisciplinary collaborations and how participants achieve them are of significant theoretical interest, as well as a matter of growing concern to funders and grant recipients alike.

In this paper, we propose a conceptual framework to explore these questions and provide findings from our empirical analysis. Specifically, we advance the construct of "*shared socio-emotional-cognitive (SSEC) platforms*" to capture various dimensions of successful interdisciplinary collaborations. Our approach, premised on the idea that effective interdisciplinary synthesis requires a common platform for exchange, departs from available accounts of interdisciplinary collaborations in two significant ways. First, whereas available theories concerning interdisciplinary interchange often have a focus on either the cognitive or the social dimension, we integrate the cognitive with the social, and also highlight the significance of the emotional, as well as the way institutional factors shape these three dimensions. We ask such questions as: How do collaborators interact with one another cognitively while negotiating trust, scientific authority, individuality and group belonging? How do groups build collective engagement, sufficiently agreed-upon working styles and a relatively bounded shared identity? How does the emotional experience of collaborators affect

the development of their project? How do funder practices affect these multifaceted processes of interdisciplinary collaborations?

Second, our analysis is based on an extensive empirical study of nine research networks. We place investigators' perceptions and experience on center stage. Based on the accounts of interdisciplinary collaborators, we inductively identify what constitute effective platforms for interdisciplinary synthesis, how they operate, and what factors facilitate the creation and sustenance of such platforms. In addition to their explicit references to indicators and factors of success, we also present several mechanisms through which our participants created and sustained a productive space for interdisciplinary synthesis. This is based on our analysis of the extensive interview data, which covered a number of aspects of interdisciplinary collaborations, from motivation for participation to group dynamics to tangible products of collaboration.

Our nine networks are supported by three funding institutions: the Santa Fe Institute; the MacArthur Foundation and the Canadian Institute for Advanced Research. The length of existence of these networks varies from one to eight years. They include from eight to fifteen network members each, and each network brings together scholars from at least three disciplines. Thus these networks would be considered as interdisciplinary by most standards and are explicitly described as such by their members. Researchers engage in collaboration with the support of various funding organizations or foundations, which view these networks as tools for shaping the research frontier of particularly vibrant or promising emerging or already institutionalized intellectual communities. Table 1 provides a list of these research groups while Appendix A provides details concerning case selection, data collection, and data analysis.<sup>2</sup>

In what follows, we review relevant literature on interdisciplinary collaborations. We then advance a definition of *SSEC platforms*, characterizing key dimensions and the theoretical assumptions on which they stand. The bulk of the paper elaborates the concept by describing various dimensions of a successful interdisciplinarity or SSEC platform and what factors contribute to its success. We move from the *cognitive-intellectual dimension* (most exclusively concerned with the substance of interdisciplinary work), to the *emotional dimension* (concerned with excitement, dislike, and reciprocal appreciation), the *socio-interactive dimension* (concerned relationships, meaning making and emerging work styles), and the *institutional factors of success* (concerned with how the rules and setting of intellectual production and diffusion affect collaborative interdisciplinary work). Our data show that such institutional factors as funder practices and expectations are significant in providing a context that shapes – but not necessarily determines – the workings of SSEC platforms. We conclude by comparing our construct with a highly regarded model for understanding interdisciplinary exchange: the notion of “trading zones,” proposed by Peter Galison (1997).

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<sup>2</sup> While we identify the organizations we studied and compare them in factual terms (e.g. number of members per networks, length of life of networks), we abstain for specifying which one performs best on the various dimensions of success under consideration in order to respect agreed-upon conditions of participations. Thus our tables are presented in such a way that the specific foundations and networks cannot be identified.

Based on the analysis of these dimensions and informant accounts on their collaboration in general, we have identified several mechanisms

In what follows, we describe a number of dimensions and group phenomena that our informants presented as indicators of successful interdisciplinary collaborations and factors that facilitate them (See Tables 2 and 3).<sup>3</sup> These tables detail the relative frequency of these elements of our three dimensions and factors of success that they explicitly discussed without our prompting. We will see that these elements are present for all of our networks, albeit with variations in emphasis across programs. Moreover, these tables demonstrate the empirical soundness of conceptualizing interdisciplinary success as a multidimensional reality that centers not only on cognitive achievement, but also on emotional and interactional dimensions. We also present mechanisms that we have inductively identified from informant accounts that sustain such collaborations in each dimension. Whereas we present various elements of SSEC platforms as part of a cognitive, emotional or social dimension for the sake of analytical clarity, they reveal the deeply intertwined nature of such dimensions. This further highlights the relevance of our construct in contrast to the notion of “trading zones” (Galison 1997).

## Background

While the propagation of interdisciplinary initiatives has resulted in an increasing demand for studies of interdisciplinarity, debates over what constitutes interdisciplinary work are longstanding (Boden 1999, Klein 1990, 1996, Kockelmans 1979, Lattuca 2001, Miller 2006 OECD/CERI 1972). Research has focused on organizational aspects, assessment and funding problems, institutional obstacles, and mechanisms for its promotion (Chubin et al. 1986, Huber 1992, Klein 1990, Klein 1996, Newell 1998, Weingart & Stehr 2000). In this paper, we adopt the American National Academies of Science definition of interdisciplinary research:

IDR is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance a fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline.

National Academies 2005 p.2

The definition is productive: It highlights group and individual researchers’ work. It emphasizes the disciplinary grounding of interdisciplinary research practices--challenging the view that interdisciplinary work is a- or anti-disciplinary (Weingart 2001). By considering “areas of specialization,” the definition elegantly overcomes ongoing debates about how disciplinary boundaries are to be drawn. Interdisciplinary efforts are viewed as purposefully advancing fundamental or practical understanding, and the integration of perspectives as central to the task (Boix-Mansilla 2010).

Despite growing empirical efforts to study interdisciplinary practice, rarely have researchers tackled the “heart” of interdisciplinary insight—i.e., the phenomenon of *interdisciplinary integration* and the *human conditions* that make it possible. A small number of available conceptualizations highlight particular dimensions of integration. They serve as bases or counterpoints for the theory of *interdisciplinary platforms* we propose. For example,

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<sup>3</sup> Our tables present eight groups, instead of nine, as we have collapsed two groups (funded by the same institution) into one due to the small numbers of their members and the respondents we were able to interview.

studies taking a cognitive/epistemological approach have identified a variety of disciplinary integration styles in interdisciplinary research: *conceptual-bridging*, *aesthetic-synthesis*, *comprehensive*, and *practical*. Each approach embodies its own cognitive mechanism for integration and validation criteria (Boix Mansilla 2002, Nikitina 2002, Miller 2006).

Studies in a social psychology tradition draw attention to the social aspects of interdisciplinary work. They suggest that experts doing interdisciplinary work engage in *cognitive apprenticeships* outside their discipline (Lattuca, 2001) and acquire *interactional expertise* (Collins 2004, Collins & Evans 2007)—they learn to collaborate effectively without becoming deeply knowledgeable of, or contributors to, each others fields. Collaborators coordinate their distributed expertise through *integrative products*—i.e. tools for interdisciplinary exchange (DuRussel & Derry, 1996; Derry, DuRussel, & O'Donnell, 1998). Through *perspective-taking* they make sense of their collaborators' expertise and establish *common ground* in group communication (Bromme 2000, Bromme & Nückles 1998, Clark 1992).

Peter Galison (1997) applies the anthropological metaphor of economic *trading zones* to describe how scholars from different scientific traditions were able to establish a common ground for their local exchanges, without global agreement. Similarly, Star and Griesemer (1989) emphasize the integrative role of *boundary object*—objects, repositories, ideal types—plastic enough to be interpreted differently by the disciplinary parties employing them, yet robust enough to maintain a common identity across contexts.

In sum, research on interdisciplinary integration has dealt with either cognitive/epistemological or social-interactive concerns, and few studies have attempted to integrate such perspectives. Moreover, few studies have captured the emotional and identity substrates that weave interdisciplinary groups together in more or less successful ways. Consistently, however, our interviews revealed the saliency of emotion, academic identities, and preservation of self as fundamental factors propelling or impeding the group's work. Our findings show that these expressions, rather than being epiphenomenal or external to, or infringing on, interdisciplinary collaboration, occupy central stage as underlying explanatory forces giving meaning to human behavior and setting conditions for collaborative success.

### Shared Social-Emotional-Cognitive (SSEC) Platforms

We define a shared socio-emotional-cognitive (SSEC) platform as a collectively constructed *space* in which participating individuals engage socially, emotionally, and cognitively to examine a relatively common problem of study and advance productive insights through interdisciplinary exchange. We draw on insights from science studies and symbolic interactionism in identifying the constructed, multi-dimensional nature of this space. Drawing insight from pragmatism, we also view the content and constitution of the platform as “in the making” (Camic, Gross and Lamont 2011) and thus potentially unstable, and characterized by relatively blurred boundaries: actors attach their own research agenda to the common platform with commitments that vary in intensity, depth, and duration. Participants can be guided by practical concerns or by deeper, more permanent intellectual/personal principles and values. They may be more or less eager to define shared tools and concepts, so as to leave themselves and others the freedom to interpret them in a pliable fashion. Thus, notions of “success” and “purpose” are malleable, relatively transient, and interactively calibrated (Boix Mansilla 2010, Lamont et al 2007, Lamont 2008).

The three dimensions of SSEC platforms – *cognitive-intellectual*, *emotional* and *socio-interactive* – are analytically distinct, yet mutually constitutive in significant ways, as stated earlier and shown in our findings below. The *cognitive-intellectual* dimension captures the cognitive substance of the work: the problem under study and the meanings individuals attach to it. The *emotional* dimension refers to how participants emotionally engage with the shared project and with its ideas, as well as with other participants. It manifests itself in how group members describe their excitement, the collective effervescence generated by shared intellectual pursuit, and the annoyance they feel toward group members who move the collective agenda in directions that are orthogonal to their own vision of the group. Thus this emotional dimension is deeply intertwined with the intellectual and interactional dimensions. The *socio-interactive* dimension addresses the ways in which individuals’ relationships with each other weave the symbolic fabric that maintains the network together and give rise to the emerging customary rules--rituals, expectations, standards, habits and artifacts. These social elements are also significantly constitutive of the cognitive trajectory of collaborative work and the emotional experience of participants. (Again, these dimensions of SSEC platforms are also factors of explanation for their relative success. Thus below they are described as dimensions of SSEC and as conditions for success.) Finally, we focus on the *institutional* factors for the creation of SSEC, which embody the larger context in which interdisciplinary research networks operate. Here material and organization resources are crucial, but so are institutionalized expectations about group interaction that are communicated to researchers – through scientific cultures that provide models about risk-taking and discovery. In what follows we examine each dimension in detail. We reveal the qualities that our participants attributed to “successful collaborations” and we explore the underlying social, emotional and cognitive dynamics that foster or impede such success.

### The cognitive-intellectual dimension: the quality and the “right” mix of expertise and productive problem framing

This dimension of SSEC platforms addresses the substantive aspects of an interdisciplinary network’s work. It includes the problems deemed significant and worthy of interdisciplinary study; the selection of adequate inputs in the form of collaborators, preferred theories, and methods from various disciplines or interdisciplines; and the criteria by which findings are validated.

Our respondents defined success in this domain in multiple ways (See Table 2).<sup>4</sup> The majority of them emphasized the significance of learning from each other in the way that change their own research. Many view as indicators of success not only disciplinary excellence and originality of interdisciplinary leverage, but also conditions for further productive collaboration, such as common intellectual ground for exchange and generative possibilities of their collective work.

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<sup>4</sup> While this section discusses primarily productive problem framing, as shown on Table 2 and 3 other intellectual dimensions of successful interdisciplinary collaboration include the scholarly caliber of members, how to leverage knowledge integration, and how to assess critical contribution. Other key constructs are simultaneously cognitive, emotional and social. They include collective effervescence, cognitive emotions, and intellectual admiration. These dimensions could be described as underlying dynamics explaining and sustaining the platforms’ work.

As intellectual factors for successful interdisciplinarity, our respondents considered the substantive expertise that each participant brings to the table to be essential (See Table 3). Discussions about recruitment focus in large part on what complementary knowledge is needed to address the question at hand, and which disciplinary expert is best equipped to engage productively with the types of knowledge already available in the group. Importantly, our respondents chose new members on the basis of not only the quality of their expertise, but also their intellectual openness, interactional styles and personal dispositions. Recruitment processes mattered immensely in identifying “the right kind of” people in terms of their cognitive *and* social qualities.

Network members also consider productive problem framing as an important factor for success (See Table 3). Topics are framed in interdisciplinary terms with the goal of capitalizing on varied expertise and yielding insights that would not have been possible through single disciplinary means. They described problem framing as an iterative process occurring at the intersection of prior knowledge (seminal papers, prior results), group membership and interests, identification of gaps in current knowledge, and new problems requiring an interdisciplinary approach. Members seek to define their collective foci and intellectual agendas in shared but “optimally ambiguous” terms: open enough to invite and facilitate participation and multiple ownership, and closed enough to empower meaningful exchange. This ambiguity is one of the most important characteristics of SSEC platforms, as it allows for forms of engagement that can be custom-fit to the needs of each participant and facilitate alignment between each member’s intellectual interests and the collective endeavors.

For example, in one network we studied, a group of scholars agreed that if “Successful Societies” stood as a broad and unmanageable construct to define the network’s agenda, the subtitle “how institutions and cultural repertoires affect health and capabilities” would sufficiently disambiguate the topic. Each construct included in this frame serves as an intellectual stepping stone for scholars from different disciplinary traditions to join. These researchers chose not to have a single and tightly-bounded “unifying research question”. Instead they opted for a more flexible model oriented toward interconnected but “multiple promising areas of convergence.”

The broad intellectual mission of each of the groups we studied —e.g., to characterize successful societies, expand economics, or redefine genes—is also collectively negotiated, with program directors exercising variable degrees of leadership, but rarely dictating research directions in a strict manner that would preempt enrolling creative talents. Our respondents considered this collective intellectual mission and a shared sense of mutual need and commitment to be significant for successful integration (Table 3). They organize how researchers experience the network by providing a schema for making sense of particular disciplinary contributions and overall progress. They also organize how researchers experience their own commitments to particular lines of research and their professional goals, calibrating, as one investigator put it: “the sense of myself as a scholar”.

In sum, the intellectual dimension of a SSEC platform encompasses not only disciplinary complementarity and the qualities of individual participants and collaborative work, but also mutual learning, common intellectual ground for exchange and a shared mission. Successful framing of intellectual agendas involves not only consideration of extant knowledge, leveraging innovations and strong disciplinary grounding but also the frame’s capacity to engage investigators’ diverse intellectual biographies in flexible ways. The interdisciplinary nature of the work amplifies opportunities for surprise, discovery as well as

cognitive dissonance, overload and confusion. The cognitive aspects of collaboration evolve over time through interaction, and the significance of productive interaction and its sustenance means that desirable and necessary participant qualities go beyond the realm of the purely cognitive. As we suggest below, the emotional and socio-interactive dimensions are *constitutive* of the cognitive life of a SSEC platform.

### The Emotional Dimension: “Getting Excited”

Sharing in the collective task they view as a unique opportunity to tackle challenging questions in innovative and creative ways energizes participants in the group individually and collectively. Cognitive engagement with the shared problems of inquiry is certainly key: Researchers join networks committed to problems that “occupy their minds.” At the same time, the meanings participants attribute to these problems and the emotional experience of intellectual excitement such problems elicit also constitute crucial elements of the collective efforts at synthesis. To the degree to which they can attach their topics of interest to the problem spaces framed by the group and experience a renewed sense of “flow,” or positive emotions that sustain their “love of work”(Neumann 2006; Csikszentmihalyi 1990), researchers are inclined to commit to the common research agenda – “absorbing questions” – and experience greater solidarity with members of the group. Thus, emotions are one of the important components of SSEC platforms, as well as one of their conditions of possibility that anchor intellectual engagement and participation in the network and promote or hinder its success. The majority of our respondents addressed affective indicators of their ID collaboration’s success—the “joy” of working together, “shared excitement” about the work. (See Table 2). Analysis of their accounts revealed an emotional architecture of successful collaborations involving not only individual intellectual excitement as described above, but also collective effervescence and the dynamics that contributed to the preservation of their academic identities. Concepts such as *cognitive emotions* (Sheffler 1977, Elgin 1999) – i.e. emotions associated with epistemologically relevant experiences in knowledge production – and *passionate thoughts* (Neumann 2006) help explain the individual emotional experience of intellectual work. Our data show that they arise frequently in interdisciplinary exchange both at the individual and collective levels. Maintaining collective effervescence (Durkheim 1912/1995) facilitates ongoing adjustment of the frame - one that meets at once emerging interests of participants in the group and the recalibrations and redefinitions of problems that take place as a network evolves.

Naturally, emotional experience of collaboration is not limited to the positive. The “joy of discovery” that stems from recognizing that scholars in an entirely different discipline characterize the common problem of study in forms analogous to one’s own, is mitigated by the “frustration of incoherence” experienced by collaborators failing to align their mental models of the same problem. The emotional experience of “surprise” and “painful disorientation” that takes place when new theories or findings being shared conflict with prior expectations may lead researchers to re-commit themselves to collaborating, or to become more reluctant to do so. This experience that is both cognitive and emotional is often rooted in internalized rational academic norms and intellectual values such as love of truth, concern for accuracy in observation and inference, and disdain for error or lie. They filter participants’ experiences in a research network and orient their behavior. As one theoretical physicist put it:

And suddenly there's revealed this extraordinary connectivity and unity. And the thing that excites me, as a scientist, is finding commonalities, unity and sort of

underlying, I call them laws.... And then using those to ask what was in fact the underlying dynamic that led to this? That's very exciting....\_And the thing that's made me so excited is that all that stuff out there, which is now very relevant, which looks like a big mess, has extraordinarily elegant structure to it, which I never realized. And that is to me just so exciting. If I were religious, that's what I would pray to. It's very spiritual actually. I really believe that.

In fact, neuroscientists argue, emotions serve an orienting function in cognitive endeavors. They are involved in selective attention and attention monitoring as much as they help encode memories in the brain (Immordino-Yang & Fischer 2009). Because emotions underlie individual's prior experience and commitment to particular lines of research, they orient researchers' intuitions about which newly presented insights, theories, or lines of thought are more "salient, motivating, and exiting." Further, during the moment to moment thinking involved in the creation of a framework or the resolution of a problem, emotions, encoding tacit knowledge, offer visceral markers of "a sense that we are moving in the right direction" or a "feeling that a line of thought is astray" (Immordino-Yang & Fischer 2009). As one informant put it: "There's a sense of progress, there's a sense of achievement, and I think there's a general sense of satisfaction that's interesting". Higher order cognition, neuroscience findings suggest, is guided by a somato-sensory rudder that is emotional.

Clearly, researchers experience many emotions (pleasure, admiration, connection, even intimacy) that are intertwined with the cognitive and socio-interactive dimensions of the collaboration. Some emotions are both a by-product of regular interaction and a constitutive element of the fabric of interpersonal relationships that emerges from a partnership sustained over time. They include feelings of being appreciated, that one's expertise, judgment, or interpersonal skills are admired or honored by others, and on the flip side, the feelings that one is "dissed," not valued or not fully integrated in a collective project. Although these impinge directly on cognition, or on the desire to contribute to a collective project, we view them as resorting also from human interaction and address them under the socio-interactional dimension of SSEC platforms.

### Socio-Interactional dimension: "People you would want to dwell with"

This dimension of SSEC platforms embodies the ways in which participants interact with their peers based on the meanings they attribute to them. It captures, in turn, how such interactions create a symbolic network that enhances or hinders interdisciplinary work and give rise to a group's unique emerging working style. This dimension contains the processes by which individuals build (or fail to build) trust, belonging, meaningful attachments, and a groups-specific "way of doing things." Individual identities serve as the backdrop against which participants interpret their experiences and evaluate themselves and others, but there are a range of emerging group-level qualities that continue to evolve and shape their experience. The majority of our respondents privileged a growing capacity for deliberation and learning as a crucial sign of success as an interdisciplinary group (see Table 2). Other interactional dimensions for success include a shared sense of group identity, the building of meaningful relationships, shared view of the group as having strong collective moral norms supporting trust, and the existence of shared working styles. Many respondents also defined success in terms of the joy of collaboration and meaningful connection with their peers.

The socio-interactional conditions for success include the construction of a collective identity, climate of conviviality and openness, and participant qualities like sociability and status (See Table 3). Collaborators are inclined to withstand the efforts of interdisciplinary dialogue not only because they value its intellectual rewards, but also because they enjoy the sense of belonging and trust such groups engender, and they appreciate the opportunity to work with peers whose stature, competency, and intellectual dispositions they respect. Their commitment goes beyond strategic, career-advancing objectives or material interests such as funding or professional networking. They report the *pleasures and excitement* of working together on something “exciting and interesting” and building “meaningful and long-lasting relationships.” Thus, we view the interactional and emotional dimensions of SSEC as constituting themselves reciprocally, in interaction with the cognitive dimension.

Our respondents evaluate their collaborators vis-à-vis *quality and significance of work* (including disciplinary competence, methodological rigor, communication skill, and substantive fit) and a *disposition toward openness and interactivity* (including sociability, humility, curiosity, risk taking and capacity to listen). Belonging to such esteemed collection of peers invites researchers to identify with their colleagues, as the collaboration reflects well on their concept of self. Identification engenders trust and feelings of solidarity. These positive feelings are a key dimensions associated with successful interdisciplinarity or productive SSEC platforms for our respondents (See Table 2). Respected peers are viewed as essential partners in the morally charged search for new paradigms and novel frontiers and relevant solutions. As one individual put it:

I was impressed by the quality of the scholars around the table, [their] competence, open-mindedness, curiosity, kindness. I sensed that these people had the possibility to achieve something original and remarkable.

The recruitment process is key to ensure these qualities —especially when participatory. In it, established network members construct a shared sense of the profile of scholar that “belongs” in the group, given the group’s attributed “original and remarkable” charge. “We work very hard to get collaborators of a particular sort, explains one informant, and of course the key criterion is a certain kind of intellectual liveliness that is typically known as effective interaction.”

What we really are interested in is not just people who can bring a particular expertise, or even who have a kind of a style that’s congenial to collaboration, but also who think in penetrating ways about ways that are not their own area of expertise [...] It’s a matter of, how much are they willing to put their mind into the collective enterprise.

Further, exchanges enable participants to continue to distinguish the group—ergo themselves—from “less appealing” candidates or less values intellectual traditions. For example in describing why a candidate was not selected, an individual explains:

There was one [candidate] whose identity of being an economist was so strong that they couldn’t entertain challenges to it.

Cognitive “boundary work” (Lamont and Molnar 2002) is an important interactional factor for success. It enables participants to deepen their identity as a group, engender trust and a strengthen belonging among likeminded and esteemed peers. Multiple factors may define the

bounded group: from “being a group of fringy economists” to “being SFI” an adjective that denotes voracious curiosity, adventurous intellect, capacity for dialogue, and a strong inclination toward mathematical rigor. The corollary of this form of boundary work is individuals’ strong identification with shared qualities of members of the group as “people you would want to dwell with.” (Lamont 2009). As one economist illustrates it:

...you’re doing something [in economics] that’s a little bit off the beaten path... you’re sort of in your office... it’s a very different experience than when you’re going into a room where everybody is interested...the benefits are that you have a community with whom to bounce off ideas

Identification is not a simple process in interdisciplinary terrains. Through continuous interactions, interdisciplinary collaborators come to make sense of the worldviews and working styles of scholars whose lives and minds have unfolded in different disciplinary traditions. Interactions also enable researchers to recognize intellectual fault-lines that stand between them in the form of mutually incompatible epistemic commitments or historical disciplinary disputes. Social contact outside meetings proves key to establishing the personal trust that can survive often drastically different epistemological orientations. It enables a “propitious meeting of minds” and “emerging networks of shared interests.”

Through an iterative process of calibrating impressions of others and self, these researchers build attachments with particular members of the group. Often attachments have deep emotional roots that mark the “extraordinary commitment to one another necessary to overcome barriers of language and disciplinary cultures”:

The thing that made it succeed in the end was the real commitment we made that we were going to try to do this and work on it together and really try to understand each other. I often liken it to a marriage. That’s a real commitment! You love them you hate them they drive you absolutely up the wall. They do things that piss you off but they also do some of the most wonderful things you know.

In interdisciplinary collaborations peers serve as reference points and identity mediates interactions. Deliberations e.g., over the significance of particular constructs or the strengths of contending methods, provide participants with a context in which to measure themselves against others. They also enable them to value others for their contributions to the collective work deferring to their expertise. For example, one non-economist contributes to the work of established economists and is recognized for his expertise. His experience plays an important role in affirming this researcher’s identity. “I feel good about myself,” he explains, “when I can contribute to the work of these very well known economists.” The accomplishment is especially striking against the background of traditional dynamics of disciplinary prestige.

It follows that interdisciplinary collaborations play a significant role in the maintenance or transformation of participants’ academic identities and are consequentially imbued with emotional salience. To the degree that interactions confirm researchers’ conceptions of themselves and their roles in the network—positive emotions can be expected and with them trust (Turner & Stets 2005). Interactions may fail to confirm participants’ self concept—e.g. by failing to recognize the significance of a participant’s disciplinary perspective. These interactions yield “self awareness”, discomfort, the need for self verification and investment in emotional work. Occasionally they also yield a new intellectual path. For example, one

informant describes the struggle over dominance of the intellectual terrain between a sociologist and a public health colleague in the group.

That, [my recent work on institutions] was the part of me that group was interested in. So when [this group member] said all this stuff about biological health, [. . .] I was starting to sort of lose the argument because what could be more important than saving babies' lives? So I got sort of irritated. [. . .] In other words, if you really think institutions are important then even if this is the greatest thing in the world, you need to figure out why societies decided to do that [saving babies]. And that just caused a huge light bulb to go off in my head. So, the question that is that it was being provoked, it was being provoked by somebody who really was a competitor for influence in this group [. . .] so for me, I thought oh my god, that's fascinating. And it changed the next ten years of my life. And the rest of my life. For as long as I stay professionally active, this is what I'm working on. I don't want to do anything else, I just want to do this.

Blow by blow, these researchers' interactions create a symbolic network that holds the groups together and contributes to the creation of a repertoire of customary rules—more or less shared expectations beliefs and behaviors regarding intellectual values, deliberation styles, distribution of labor, and artifacts, and that constitute “the way we [the group] do things.” Rules organize members' behavior but they also contribute to the group's identity formation.

The creation and maintenance of a “climate of collegiality” and “trust” is viewed as essential to create a positive sense of the group (See Table 3). As one respondent put it:

In a sense we're creating a community... you can tell when things happen that build trust [...] a sequence of positively shared experiences and exchanged views just raises the trust level and engagement to a higher level, and that means it's working.

Our respondents construct such a communal climate through value-laden and tacitly-coordinated interactive routines that include deferring to their peers' expertise, exhibiting innocence in domains other than their own, demonstrating proactive curiosity, and sharing expertise generously when needed. Values and routines structure what eventually becomes acceptable behavior for the group and give rise to an emerging archetype of “the good interdisciplinary collaborator” which in turn informs adjustments in individual behaviors, group identity and shared routines. For example, describing the ways in which members manage status differences, one informant explains:

Frankly, I don't feel that there is negotiation of status and respect. I don't feel it, I don't sense it towards me that, again, maybe an issue of self-selection. So when you are a self-selection of people who aren't going to be trading on status... I don't want somebody who is going to trade on status, what I mean by trade on status is someone who feels like their comment is more important.”

“Collegiality” means not “distant respect.” Rather it is a *sine qua non* component of a trusting atmosphere for open debate and polite argumentation. Epistemological disagreements, struggles over the dominant agenda, and disciplinary fault-lines are at play pushing individuals to sharpen their argumentative tools or transform their views productively.

They [the conflicts we have] tend to be around those kinds of issues: the relative role of material resources versus social status and its impact on people in terms of how they go about their lives. And it's easy to caricature either side of it, right? So we spent a lot of time particularly early on visiting those issues and really pushing hard on them. When you find a source of conflict-- or it comes up as a conflict, it's always very cordial, and I don't mean it's heated conflict—in my experience with this group and other groups, the only way to [go about] it is to just go at it full force, like what is the real issue here, not let it fly, right, not let it go past. And I think this group is very good at doing that.

Deliberations enable researchers to evaluate their interpretations of their peers' perspectives and calibrate their own. Furthermore, they offer opportunities for researcher to craft and enact 'roles' that are often informally adopted and exchanged. For example, individuals may play the role of a "trustworthy convener" because their stature warrants quality and prestige in the eye of invited participants. Individuals play out their "disciplinary reference" role when they offer disciplinary background and corrections. They take on a "meta-disciplinary analyst" role when they are aware of the disciplinary modes of thinking represented in the group and can make participants' assumptions about knowledge and research explicit to support mutual understanding. Researchers play "synthesizer" roles when they advance the integration or perspectives by framing disciplinary contributions into coherent and provisional wholes. "Focus- or task- stewards" find themselves reminding the group about the essential aspects of their collective mission and enlisting their alignment with it. Some networks seek out "intellectual critics" for their work.

Emergent informal roles coexist with formally assigned leadership roles. In some groups leaders display their authority by establishing very horizontal dynamics (e.g. between a Nobel laureate, senior and junior scholars and postdoctoral researchers). Other groups—especially those mobilized by a specifically articulated task (e.g. redefine the gene concept) see the benefits of leaders who present initial framings of the problem, coordinate disciplinary inputs (calling up "just in time" expertise in the group), or selecting integrative artifacts in the form of shared graphics, narratives, memos, conceptual models, or collective volumes to support the group's integrative mandate. Artifacts provide a visible, shared and practical space for disciplinary integration---a concrete space for interacting, and engaging in disciplinary translation. Artifacts become part of the symbolic repertoire of the group weaving it together.

In sum, the socio-interactional dimension of SSEC platforms captures the social relationships and systems of meaning that weave an interdisciplinary group together. This dimension attends to emerging group styles or repertoire of behaviors, beliefs, values and artifacts collectively constructed through blow by blow interactions that serve as a shared toolkit to advance collaborative life and work. Academic identity and self enhancement are essential driving forces underlying interactional dynamic and are especially worth attending in interdisciplinary contexts marked by the heterogeneity of disciplinary choices. Relating to individuals whose disciplinary values and life-long commitments contrast with their own invites researchers to reflect on (and often calibrate) their biographical preferences--and the prestige, status and power associated with these. Because participants in a SSEC platform cannot assume shared values and intellectual orientations, they tend to wear their identities in their sleeves—through careful and frequent self-presentations and clarification of values and commitments. Successful collaborators manage to create a culture of trust, innovation,

excitement and belonging on this delicate and complex interactional foundation. Again, this culture is both a feature of SSEC platforms and one of their conditions of possibility.

### Institutional factors: “Scientific venture capitals”

Institutional factors refer to the organizational context in which interdisciplinary research groups conduct their work, the constraints these place on research, and the framework provided to them by their funding agencies, including modes of funding, reporting and accountability, how decisions are made by funders concerning what/who to support, and tools that they use to create, sustain, and nurture SSEC platforms (See Table 3).<sup>5</sup> These institutional factors influence how individuals involved in the process (researchers, program officers, and funders) define success and interpret their situation. For example, informants in our study pointed to the importance of alignment among individual, group and institutional missions vis-à-vis the general purpose of the collaboration. As we will show, purposes and their degree of specificity varied across groups but helped define group membership as well as productive patterns and pace of interactions. Our informants also viewed modes of funding and budgetary decisions as affecting the social dynamics of the group. Finally, most informants appreciated their funder’s rather hands-off management style as enabling – indeed encouraging – them to envision creative solutions to their problems of study with minimal bureaucratic concern. Here too a dynamic of institutional trust and substance emerges as a fundamental condition for success.

In her research on epistemological cultures, Karin Knorr (1999) discusses the technologies that constrain and enable research in the case of high energy physics and molecular biology. These include modes of coordination and evaluation, such as peer review, processes by which various types of resources are distributed, organization supports and requirements for group meetings, etc. Her research inspires our thinking concerning how the institutional dimension facilitates and preempts various ways of organizing interdisciplinary collaboration. We find that the three funding organizations set different objectives and use different types of technologies to fund and organize the work of their interdisciplinary research group. These result in different definitions of successful work, patterns of interaction and levels of mutual interdependencies, and presume different modes and time horizons for product delivery and accountability.

Funders’ expectation has a direct influence on the work of program members. For instance, where the funder (CIFAR) encourages a pursuit of “big questions,” without tightly specifying expected deliverables or formally requiring collaborative research among members, members are aware that they are expected to meet regularly (3-4 times a year) and produce significant intellectual contributions in the end. Another funder (McArthur Foundation) is explicit about its expectation of collaborative outcome having practical and direct implications for society, and this is evident in the ways in which its members defined their success along the same line. A third funder (SFI) also supports highly innovative, exploratory research projects without imposing concrete deliverables, but its networks are smaller-scaled and shorter-termed than the other two, and their collective problem-frames tend to be more narrowly defined. .

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<sup>5</sup> As we mention in footnote #4, due to our agreed-upon conditions of participations with funding organizations, we choose not to specify network identities in our tables in the way that would show the clear differences across funders. This obscures the salience of certain qualities distinct to one or two funding institutions.

Naturally, funding is a key element that significantly shapes the nature of interdisciplinary collaborations. Funding varies not only in the amount and duration, but also in the conditions under which awards are made. Some organizations invest in individual researchers, while others fund research projects, allowing groups leaders to allocate the funds to internal projects. Yet others support their own full-time faculty, who initiate and participate in interdisciplinary collaborations with others. Such differences have significant ramifications for group dynamics, qualities required in leaders, and the styles and practices of actual collaboration.

For instance, long-term funding and explicit support for big questions afford network members the unique luxury of slowly defining shared problems of study, developing personal trust and a sense of community, and building common languages and group rules. Generous funding of individual researchers allows them to be freed from teaching at their home universities to conduct their own research, but might not necessarily motivate collaborations in the same way as the networks that fund internal projects. The emphasis on “big picture” questions certainly entails a risk of not producing anything coherent or practical, but encourages innovation in a unique way. As one interviewee put it:

I must confess at first I was surprised at the lack of more concrete requirements and felt quite vague about what we were supposed to be doing, though I really enjoyed all the discussions and was getting lots of new ideas, etc. Now, I think that not imposing a set of specific deliverables is very freeing and thus encouraging to ‘try something new and different’ even if it might not work out right away. There is more space to take academic risks.

Institutional expectations can be a productive catalyst for integration. One network considered the publication of a book that recapitulates the intellectual advances from the first five-year term to facilitate the renewal for the second term. For this network, this fixed deadline served as a powerful incentive to intensify the integrating efforts among the members.

Another funder’s shorter-term, “venture-capital” approaches and limited resources cultivate a different intellectual climate in its networks. Participants are highly dependent on each other for their specific expertise. The lack of funding presents obvious challenges such as time constraints on participants, but it also fosters a distinct sense of commitment and solidarity (“I don’t think anyone here does it for money.”) and allows the kind of agility and flexibility only possible in the absence of onerous obligations to the funder. Many participants emphasize their enthusiasm about their pioneering work:

...we do it because we really enjoy it. And you can call us cowboys or something. But that’s the spirit... a lot of people here are very respectable and I guess we try ultimately, I mean, we do scholarly work. But the idea of that is that...you’re not stopped by the fact that there are questions outside your domain...you just go, ‘OK, that’s an interesting question. What do people know about that question?’ You ask around... And the big question is usually enough.

Finally, institutional factors for interdisciplinary success also encompass the larger context of academic institutions. First, depending on their specific reputation and prestige within the academia, foundations attract different types of researchers and add different kinds of cachet to the participant’s career. One funder’s reputation for its maverick and high-intensity

enterprises appeals to particular types of scientists. Second, disciplines are differently open to interdisciplinary collaborations. Economists are at times described as facing unique challenges in participating in interdisciplinary projects that sociologists might not. Because of the more uniform nature of epistemological and methodological approaches in economics, economists might be intellectually less interested in such collaborations, or less likely to benefit from interdisciplinary work in advancing their career.

In sum, the institutional factors have direct impact on the three dimensions of SSEC platforms. Characteristics of funding practices and foundation expectations crucially shape intellectual enterprises, group culture, and working styles of interdisciplinary collaborations. The standing of each foundation, as well as different openness to interdisciplinarity of each discipline, also influence the nature of an interdisciplinary project.

## SSEC platforms revisited

The concept of SSEC platforms is uniquely productive in examining interdisciplinarity in the following three ways. First, moving beyond the definitional debates about what constitutes interdisciplinary work, this empirically grounded framework identifies common dimensions that are constitutive of a wide range of interdisciplinary collaborations. Second, by integrating multiple – cognitive-intellectual, emotional and socio-interactive – dimensions, the concept of SSEC platforms more thoroughly addresses the intricate workings of interdisciplinary collaborations than do existing concepts. Importantly, we consider these analytically distinct yet empirically intertwined dimensions to be mutually constitutive. For instance, such extra-cognitive factors as funding modalities and styles of interaction shape the ways in which the cognitive dimension of interdisciplinary collaborations evolve. Third, this framework highlights the fundamental role of emotions and, identity in interdisciplinary work. For instance, group identity emerges and strengthens among participants as they narrow down their intellectual objectives, develop interpersonal trust, establish distinct working styles and collectively deal with funding requirements. And strong group identity is often an essential element for effective intellectual integration. As is evident with this example, SSEC platforms evolve over time.

Again, some of these SSEC platform dimensions are regarded here as enabling the success of these platform. To understand what makes a collective problem exciting, one has to consider group style and norms of interaction as well as how the expertise of the various group members are brought to the table to deal with distinctive and essential aspects of the problem. The role of institutional factors in creating a context that makes this collective work possible is also of course essential. We have argued that material support, program goals, and forms of control all have a profound impact on the character of SSEC platforms.

How does the proposed SSEC platforms model compare to existing characterizations of interdisciplinary collaborations? Galison's metaphor, "trading zones" (1997), for instance, depicts cognitive aspects of interdisciplinary collaborations in an illuminating manner. Galison shows how researchers from "quasi-autonomous" domains with distinct subcultures and institutional groundings – in his case, theory, experimentation and instrumentation in modern physics – devise a local coordination for intellectual exchange without establishing comprehensive mutual understanding and agreement. In a localized zone of collaborative activity, researchers develop an intermediate set of linguistic and procedural practices that bind them together. Ideas and practices are exchanged, while they might mean different things to

researchers from different domains. Furthermore, Galison's conceptualization of such trading zones aptly addresses the nature of group learning over time in interdisciplinary projects. Mediating contact languages can evolve from "the most function-specific jargons, through semispecific pidgins, to full-fledged creoles" (Galison 1997: 783).

Whereas Galison's model touches on the interactional dimensions of interdisciplinary collaborations and institutional factors of success, it markedly focuses on the intellectual dimension and fails to address the significance of certain aspects that figure prominently in our SSEC platform concept, such as emerging group identity, development of trust, emotional engagement that underscores the intellectual commitment, and the issues of power, status and identity that shape individual beliefs and behaviors in the collective enterprises. In SSEC platforms, such aspects are not epiphenomenal, but *constitutive* of the cognitive dimension of interdisciplinary collaborations.

We have proposed and elaborated the concept of shared socio-emotional cognitive platform by describing various dimensions of SSECs. We addressed the *cognitive-intellectual dimension* (concerned with substance), the *emotional dimension* (concerned with emotional relationship with the topic of research and in the collaboration) and *socio-interactive dimension* (concerned with relationships, meaning making and emerging work styles). We have describes these dimensions as dimensions as SSECS and as conditions enabling them. Finally, we have discussed the *institutional factors* that make SSEC platform possible. These are concerned with how the rules and setting of intellectual production and diffusion affect collaborative interdisciplinary work.

Again, Table 2 details the relative frequency of the various elements of our three dimensions of success for our nine research groups. It reveals that these elements are present for all of our networks, albeit with slight variations in emphasis across programs. This table demonstrates the empirical soundness of conceptualizing interdisciplinary success as a multidimensional reality that centers not only on cognitive achievement, but also on emotional and interaction dimensions. This confirms the relevance of our construct in contrast to another highly regarded model for understanding interdisciplinary exchange, the notion of "trading zones."

This table also reveals that the cognitive-intellectual dimension is overall most salient. This is not surprising as researchers may feel much more authorized or are more interested in discussing the intellectual aspects of their work, as opposed to the emotional or interactional aspects, which they may take for granted. The framing of the interview (i.e. them being approached as members of a research group) may prime them to emphasize intellectual collaboration, whereas interviewing them as fathers or church members may have primed them to emphasize other dimensions of their lived experience.

Table 3 compares which factors of success are most emphasized by the respondents. This table reveals that some of the dimensions of SSEC platforms are also factors for success and it provides further evidence for the value of our approach. Here again, intellectual conditions for success are more salient than the other conditions. This table also reveals that respondents mention least often the institutional conditions for success. This suggest that researchers largely take for granted the conditions that make their work possible and how institutional structure shapes their work. This is not surprising in light of the emphasis put on individual creativity and genius in some disciplines at least.

## Conclusion: The Road Ahead

While we have sketched the broad lines of the concept of SSEC platforms, much remains to be done to flesh out fully its various dimensions and factors. First, we have to tease out exactly in what ways the intellectual, emotional, and interaction dimensions of SSEC platforms can also act as conditions favoring their development, as enabling and constraining factors. Second, we should provide a finer analysis of the results presented in Table 2 and 3, in order to analyze fully the markers and conditions of SSEC platforms that are painted here with a wide brush. We also need to provide more concrete illustration of the usefulness of our construct through a detailed analysis of the nine research networks that anchor our analysis. Our future research will do just that by comparing systematically whether and how each aspect of SSEC platforms manifest themselves in each of the research networks.

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**Table 1 Selected Interdisciplinary Research Networks**

<b>CIFAR</b>	<b>McArthur</b>	<b>SFI</b>
<p><b>Successful Societies</b> Seeks to understand the determinants of societal success. It builds on the premise that social experience is central to well being and affected both by institutional arrangements and the cultural frameworks used to interpret it. This network seeks to inform policy on matters of a society's health.</p>	<p><b>Early experience and brain development</b> The goal of this Network is to study the relationship between brain and behavioral development, to clarify the role of experience in brain development and to enhance the understanding of how neurobiological development and behavioral development are linked.</p>	<p><b>Urban Growth and social dynamics</b> Examines scaling patterns and projections of growth in social organizations and urban development. This network builds on a major SFI effort to understand the origin of scaling laws in biology and use the paradigm to formulate general principles of biological structure and organization.</p>
<p><b>Social Interactions and Well being</b> Seeks to investigate the social forces that are lacking in current economics and that affect people's happiness and well-being. The program seeks to extend the toolkit of economics and other social sciences, enabling a more comprehensive view of motivation and well-being that will in turn help people live more contented lives.</p>	<p><b>An Aging Society</b> Examines many critical issues surrounding the social, economic, and institutional implications of an Aging Society. For instance, how will the aging of society impact those in various socioeconomic groups disparately? The network seeks to identify the modifications required in our major societal institutions to facilitate emergence of a productive, equitable Aging Society in the United States.</p>	<p><b>Complexity and the Gene Concept</b> Examines the complex relationship between genome level sequences and phenotypic structures and functions. The network seeks to establish a new conceptual model for genetics that is better able to account for the one-to-many and many-to-one mappings from sequence to structure and function, and better able to capture the dynamical and logical nature of gene expression.</p>
<p><b>Genetic Networks</b> Devoted to discovering how genes interact with one another, with the hope of identifying the root causes of many genetic diseases and leading to new treatments and preventive measures.</p>	<p><b>Adolescent Development and Juvenile Justice</b> Seeks to expand the base of knowledge about the origins, development, prevention, and treatment of juvenile crime and delinquency. The network also strives to disseminate that knowledge to professionals and the public and improve decision-making in the justice system.</p>	<p><b>Geochemical Origins of Life</b> Seeks to understand the origins and essential properties of life. Members ponder whether life is a natural and perhaps necessary outgrowth of first principles in physics and chemistry, whether life can be synthesized, and what can minimal life forms, like viruses, reveal about life's fundamental properties.</p>

**Table 2: Markers of Success**

Groups		A		B		C		D		E		F		G		H		TOTAL	
		N=11	%	N=9	%	N=7	%	N=6	%	N=5	%	N=7	%	N=7	%	N=5	%	N=57	%
<b><u>Cognitive-Intellectual</u></b>	Disciplinary excellence and relevance (Different, key to problem, complementary, productive contrast)	0	0.0	1	11.1	4	57.1	6	100.0	2	40.0	5	71.4	1	14.3	2	40.0	21	36.8
	Experts learn from other disciplines; improved/changed own work or research agenda	5	45.5	5	55.6	6	85.7	5	83.3	5	100.0	7	100.0	2	28.6	3	60.0	38	66.7
	Clear common ground for exchange (language/framework)	2	18.2	3	33.3	3	42.9	3	50.0	4	80.0	3	42.9	2	28.6	3	60.0	23	40.4
	Original, discovery integrative	6	54.5	3	33.3	3	42.9	2	33.3	3	60.0	0	0.0	0	0.0	3	60.0	20	35.1
	Generative continuation of the research begun by the group	0	0.0	3	33.3	5	71.4	5	83.3	5	100.0	1	14.3	4	57.1	2	40.0	25	43.9
<b><u>Emotional</u></b>	Joy of working together in ID contexts	0	0.0	2	22.2	4	57.1	0	0.0	1	20.0	4	57.1	2	28.6	3	60.0	16	28.1
	Collective Intellectual excitement	3	27.3	3	33.3	4	57.1	4	66.7	4	80.0	5	71.4	3	42.9	3	60.0	29	50.9
<b><u>Socio-interactive</u></b>	Meaningful personal/intellectual ties with peers	6	54.5	2	22.2	3	42.9	2	33.3	2	40.0	2	28.6	0	0.0	1	20.0	18	31.6
	Growing deliberation and group learning competency More comfort, trust, capacity to interact productively	7	63.6	7	77.8	4	57.1	4	66.7	4	80.0	2	28.6	0	0.0	2	40.0	30	52.6

**Table 3: Factors that Facilitate Success**

Groups		A		B		C		D		E		F		G		H		TOTAL	
		N=11	%	N=9	%	N=7	%	N=6	%	N=5	%	N=7	%	N=7	%	N=5	%	N=57	%
Cognitive-Intellectual	Productive problem framing (inviting different expertise, optimally ambiguous and intellectually engaging)	3	27.3	2	22.2	4	57.1	6	100.0	3	60.0	4	57.1	6	85.7	3	60.0	31	54.4
	Clear collective mission, sense of mutual need of expertise and commitment to shared agenda	1	9.1	2	22.2	5	71.4	6	100.0	4	80.0	6	85.7	6	85.7	3	60.0	33	57.9
	Participant qualities: (Expertise, open mindedness, interest)	5	45.5	5	55.6	4	57.1	5	83.3	5	100.0	7	100.0	4	57.1	2	40.0	37	64.9
	Establishment of common ground (shared language, conceptual framework, methodology)	1	9.1	3	33.3	3	42.9	4	66.7	4	80.0	4	57.1	2	28.6	3	60.0	24	42.1
	Search for Leveraging integrations	4	36.4	0	0.0	3	42.9	5	83.3	3	60.0	1	14.3	2	28.6	3	60.0	21	36.8
	Inclination to revise, rethink and adjust frames over time. Progressive cognitive iteration moving towards objectives.	2	18.2	0	0.0	3	42.9	5	83.3	3	60.0	5	71.4	2	28.6	3	60.0	23	40.4
Emotional	Feelings of trust, respect, admiration, (identification). Feeling good about self-contributing and being recognized	4	36.4	6	66.7	3	42.9	6	100.0	5	100.0	6	85.7	1	14.3	2	40.0	33	57.9
Socio-Interactive	Effective Leadership	2	18.2	5	55.6	3	42.9	6	100.0	4	80.0	6	85.7	2	28.6	0	0.0	28	49.1
	Complementary team roles (synergies, reciprocity, team size, know how to interact in groups)	1	9.1	2	22.2	3	42.9	3	50.0	0	0.0	6	85.7	0	0.0	0	0.0	15	26.3
	Participant qualities (sociability/prestige/openminded)	3	27.3	4	44.4	4	57.1	5	83.3	4	80.0	7	100.0	1	14.3	1	20.0	29	50.9
	Strong interpersonal relations/closeness (importance of social dimension; however, respect for different individual styles: relationship vs. task-oriented)	3	27.3	2	22.2	4	57.1	1	16.7	4	80.0	6	85.7	1	14.3	1	20.0	22	38.6
	Climate of conviviality, open exchange and sense of possibility Flexible engagement in professional, constructive conversations, voices are heard)	2	18.2	6	66.7	2	28.6	5	83.3	4	80.0	7	100.0	2	28.6	2	40.0	30	52.6

		<b>A</b>		<b>B</b>		<b>C</b>		<b>D</b>		<b>E</b>		<b>F</b>		<b>G</b>		<b>H</b>			
		<b>N=11</b>	<b>%</b>	<b>N=9</b>	<b>%</b>	<b>N=7</b>	<b>%</b>	<b>N=6</b>	<b>%</b>	<b>N=5</b>	<b>%</b>	<b>N=7</b>	<b>%</b>	<b>N=7</b>	<b>%</b>	<b>N=5</b>	<b>%</b>		
	Boundary and differentiation from other groups, group identity	5	45.5	2	22.2	2	28.6	3	50.0	5	100.0	2	28.6	0	0.0	0	0.0	19	33.3
	Tasks, artifacts, group routine and working styles	2	18.2	1	11.1	3	42.9	5	83.3	2	40.0	0	0.0	0	0.0	1	20.0	14	24.6
	Social time outside of meetings	2	18.2	3	33.3	3	42.9	2	33.3	3	60.0	2	28.6	0	0.0	0	0.0	15	26.3
	Time together (in meetings, incubation)																		
Institutional	Investment in big transformative questions	4	36.4	2	22.2	5	71.4	5	83.3	3	60.0	3	42.9	0		1		23	40.4
	Investing in people	6	54.5	1	11.1	5	71.4	2	33.3	0	0.0	0	0.0	0		0	0.0	14	24.6
	Investing in research projects	0	0.0	1	11.1	1	14.3	3	50.0	3	60.0	0	0.0	0		2	40.0	10	17.5
	Investing in agile seed funds	0	0.0	0	0.0	0	0.0	0	0.0	4	80.0	0	0.0	1	14.3	1	20.0	6	10.5
	Open-ended "outcomes" (rangign from broadly open endes no pre-determined deliverables to expectation of impact in policy but no specification of means to do so)	4	36.4	3	33.3	4	57.1	4	66.7	1	20.0	1	14.3	0	0.0	0	0.0	17	29.8
	Expectation of expemprary work (tacit or explicit)	1	9.1	2	22.2	2	28.6	4	66.7	0	0.0	0	0.0	0	0.0	0	0.0	9	15.8
	Coordination with home institutions: e.g., keeping people at their universities, percentage time for university work)	2	18.2	0	0.0	0		0		0		0		0		0	0.0	2	3.5
	Central shared location for exchange	1	9.1	0	0.0	2	28.6	0	0.0	0	0.0	0	0.0	2	28.6	1	20.0	6	10.5
	Close and good relation with foundation. Low bureaucracy procedures, substance - driven loose management	4	36.4	3	33.3	4	57.1	3	50.0	3	60.0	2	28.6	1	14.3	0	0.0	20	35.1

## **Appendix A**

### **Data and Methods**

To advance an empirically grounded theory of *shared socio-emotional-cognitive platforms for interdisciplinary collaboration* we have conducted a series of case studies. A case study approach enables us to understand this multifaceted social phenomenon without losing sight of its complexity and the contextual forces that shape individuals' experience (Yin, 2008). It enables us to link our emerging theory intimately with empirical evidence of good practices and make ongoing adjustments to our data collection during the theory building process. Furthermore, because we ground our theory on multiple case analyses and our sample of research networks is theoretically driven to account for a variety of research networks varying in theoretically relevant dimensions, our approach enables us to slightly enhance the generalizability of our findings (Strauss & Corbin, 1998).

#### ***Sampling strategy***

We have conducted a close qualitative examination of six research networks<sup>6</sup> distributed among three institutions recognized for their capacity to nurture interdisciplinary research: the Canadian Institute for Advanced Research, the MacArthur Foundation, and the Santa Fe Institute. Within each institution, we selected research networks at different stages of development (nascent, midway, and completed), and representing a broad range of disciplinary emphasis and combination (from sociology, political science and economics to genetics, evolutionary biology and computer science). To the degree possible, we also sought cross-institutional comparability in terms of themes addressed (e.g. society and well being, genetic systems). To date, our grounded theory of SSEC platforms builds on six in-depth case studies of selected networks (See Table 1). Further analysis is unfolding for six additional networks.

#### ***Data collection***

We employed five means of data collection:

Internet search: Simple Internet searches enabled us to identify biographic information about our informants, ranging from publications and institutional affiliations to academic interests.

Selecting publications We selected representative papers written by our informants. We favored papers in which they collaborated with other members of the network or those that addressed the network's focus topically.

Observations: We conducted five observations of the networks at work. These included two-day meetings in which the networks hosted external speakers, deliberated on their input to the problem under study, planned future meetings. Appendix 3 includes criteria that guided our focus during observations. The criteria were used at selected moments during these multi-day meetings.

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<sup>6</sup> Please note that while only six networks are included in this submission, our final paper will draw on a corroborative study of an additional set of six networks.

Questionnaire: We administered a questionnaire to all recognized members of the network. The questionnaire addressed 4 dimensions of interdisciplinary collaborations: (1) Participants' involvement in the network: their engagement, motivations, roles and contributions; (2) The perceived dynamics of the group at work: the interactions among group members, expectations, beliefs about success, and facilitation factors; (3) The effort to integrating disciplines: selection and integration of disciplinary specialties, integration and obstacles; (4) Required structures for support: the lore of leaders, foundations, and advisors in nurturing the work of the group.

Semi-structured interviews: Between three and seven members of each studied network so far were identified and interviewed in depth. Interviews were typically conducted either during or within two or three weeks following a network meeting and most frequently upon completion of the written questionnaire. Interview questions paralleled and expanded the information obtained through the questionnaire allowing for multiple opportunities for deeper probing and clarification.

### ***Data Analysis***

Interviews were transcribed and transcripts sent to participants for review. Content analysis of questionnaire responses and transcripts yielded a coding system which was applied in two rounds of coding. First, two researchers grouped the data of each interview under the categories proposed by each code, double coding portions of the interview where appropriate. When disagreements emerged, scorers discussed the disagreements, amended the coding manual, and adjusted their codes. Working on our first three case studies we examined the data under each code to distill finer distinctions—e.g. patterned variations in approaches to collaboration, embedded tensions in the process of joint knowledge construction. This secondary analysis informed addendums to the coding system to be considered in future case studies. Finally, each case study informed the construction and revision of a preliminary model of socio-cognitive platform for interdisciplinary collaboration. Models were discussed by the research team through iterative analyses employing a grounded theory approach to conceptualization (Glaser and Strauss, 1967; Miles and Huberman, 1994).