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Towards Reconceptualizing the Core of the IS Field from a Neurobiological Perspective

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Abstract. The IS discipline has so far been unable to define the meaning of its foundational concepts ‘information’ and ‘system’. As a consequence, the core of the IS field and its relation to the IT artifact, materiality, organization, etc., are extensively discussed without reaching closure. To this end, this paper proposes a set of conceptual stepping stones towards reconsidering the core of the IS field from a neurobiological perspective. The analysis suggests that *information* can be defined as intrinsically related to individual, neural abilities for acting; and *system* as a dialectical relation between the individual and the IT artifact. As a consequence, *information system* is seen as having both an individual and social facet. These results indicate that a neurobiological perspective may open up new avenues for revitalizing the IS field.

Keywords: Information · system · activity modalities · functional systems · neurobiology · Anokhin · Vygotsky · Luria

1 Introduction

According to Beath et al, IS (Information System) research needs to attend simultaneously “the technical and the human (social) side of IT in its organizational context ... and it is precisely this combination that gives IS research its distinctive value” [1, p. v]. However, research initiatives are aggravated by the failure to establish a well-defined core of the IS field. Bedrock IS concepts such as ‘information’ and ‘system’ remain undefined: “Virtually all the extant IS literature fails to explicitly specify meaning for the very label that identifies it. This is a vital omission, because without defining what we are talking about, we can hardly know it” [2, p. 338]. Further, little progress has been made since the 1990s in conceptualization the central entity of the field – the IT artifact [3, 4].

This state of play provides the motivation for the paper, which is to reconsider the foundation of the IS field from *neurobiological* perspective. This is in line with the ambitions of the NeuroIS initiative to build “superior IS theories with assumptions and constructs that better correspond to the brain’s functionality” [5, p. 2]. However, NeuroIS contributions have so far “seldom applied specific neuroscience theories in concrete IS research studies” [6, p. 83].

As a first step towards reconsidering the core of the IS field, alternative definitions of the key IS concepts ‘information’ and ‘system’ are suggested. The line of argument proceeds as follows. First, two fundamental assumptions for a neurobiological perspective of the IS core are proposed. From these assumptions, a set of conceptual stepping stones are devised: requisite neurobiological predispositions enabling action, the dynamics of action, the structure of mental functions, the social formation of the brain, and the inclusion of brain components in mental functions. Together, these stepping stones suggest that *information* can be defined as intrinsically related to individual, neural abilities for acting. Likewise, *system* is seen as a dialectical relation between the individual and the IT artifact. As a consequence, the *Information System* needs to be reconceptualized as having both an idiosyncratic, individual facet and a communal, social facet.

In this way, the neurobiological perspective enables completely new conceptualizations of core IS constructs, which is the knowledge contribution of the paper. Hence, a first stepping stone towards building an alternative foundation for the IS field is achieved. In conclusion, such findings, inchoate as they may be, are promising enough for launching a more extensive research initiative, aimed at revitalizing the IS field from a neurobiological perspective.

2 Fundamental neurobiological assumptions

Any research program needs to proceed from some fundamental, “hardcore assumptions”, which are not questioned as long as the program progresses [7]. A first assumption from a neurobiological point of view is *that brains evolved to control the activities of bodies in the world*. The “mental is inextricably interwoven with body, world and action: the mind consists of structures that operate on the world via their role in determining action” [8, p. 527]. A second assumption is that *individuals cannot be understood* without taking their social environment into account. The opposite is also true: *the social environment cannot be understood* without understanding the individual [9]. Accordingly, the neural and social realms form a unity, which parts “cannot be separated or isolated without destroying the phenomenon that is studied” [9, pp. 336-337].

3 Conceptual stepping stones

From the fundamental assumptions, the following conceptual stepping stones are suggested towards reconsidering the IS core.

3.1 Neurobiological predispositions enabling action

The purpose of this stepping stone is to identify phylogenetically evolved, neurobiological predispositions for action, which “are universal and inherent for all humans, independent of language and environmental conditions” [10, p. 43]. Metaphorically,

such predispositions can be seen as a neurobiological ‘infrastructure’ that the individual is endowed with at birth. While providing a full account of such predispositions is indeed a prodigious task, it is nevertheless possible to consider *requisite* predispositions, i.e., necessary albeit not sufficient ones. One proposal for such predispositions is as follows [11, 12]:

- *Objectivating*: attending something towards which actions are directed
- *Contextualizing*: foregrounding that which is relevant for acting
- *Spatializing*: orienting in the environment
- *Temporalizing*: anticipating and carrying out actions
- *Stabilizing*: habitualizing appropriate actions
- *Transitional*: refocusing attention

These predispositions are termed *activity modalities*, and were devised from long-term observations and reflections in practice [13]. Importantly, all modalities are needed. A brain lesion destroying any modality will inevitably obstruct the individual from acting.

3.2 The dynamics of action

The focus of this stepping stone is the dynamics of an action. To this end, Anokhin [15] has proposed the model in Fig. 1.

Fig. 1. The dynamics of action (reproduced from [15, p. 115]; with permission).

The various stages in this model involve two kinds of functions depending on which kind of nerves are actuated [15]: afferent (going from the periphery of the body to the brain), and efferent (going from the brain to effectors such as muscles or glands). The stage ‘afferent synthesis’ perform “space-time integration on the multisensory per-

cept, a Gestalt” [16]. Based on this Gestalt, a decision is taken of “*what to do, how to do, and when to do*” [15, p. 114, italics in original]. ‘Decision making’ involves two functions – characterization of the expected result (‘acceptor of the result’), and formation of an ‘action program’. Functions in ‘efferent excitation’ enable action, after which the result modifies and stores the ‘acceptor of the result’ via ‘back-afferentation’.

3.3 The structure of mental functions

The purpose of this stepping stone is to model the structure of mental functions. According to Luria, such functions are *complex functional systems* [14]. No specific function is ever connected with the activity of one single brain center: “It is always the product of the integral activity of strictly differentiated, hierarchically interconnected centers” [17]. In Fig. 2, a model for a functional system enabling action is illustrated.

Fig. 2. A functional system enabling action (the activity modalities are emphasized)

This model shows dependencies between individual functions (which in turn may be functional systems) contributing to the overall functional system; from basic ones and progressing upwards. As such, the model illustrates how the neural system ‘comes alive’ after being shut down, for example, during sleep. In a metaphoric sense, this can be likened with starting up a car to its idling state; thus preparing it for subsequent action. The gist of the model in Fig. 2 is to show how the functional system as a whole is impacted if a particular function is inhibited by a brain damage in its contributing components. The components realizing the functions are subdued in order to focus on simplicity and critical functional dependencies.

As can be seen, the two models in Fig. 1 and Fig. 2 are related. The stages in the Anokhin model correspond to functional groups in the structural model. Together, these models capture the architecture of the individual brain at a level suitable for further inquiries into the relation between the neural and social realms. This is done in the subsequent section.

3.4 The social formation of the brain

The purpose of this stepping stone is to conceptualize how the individual and the environment mutually constitute each other. The predispositions in the neurobiological ‘infrastructure’ will develop into neurobiological *abilities* in interaction with the cultural and historical environment the individual is immersed in. Importantly, neural predispositions need to be distinguished from neural abilities. For example, many contemporaries of Julius Caesar certainly had predispositions to become pianists, but were never able to develop the corresponding ability because the pianoforte had not yet been invented [15]. As a consequence, “external aids or historically formed devices are *essential elements in the establishment of functional connections between individual parts of the brain*” [14, p. 31; italics in original].

The essence of this insight is that the development of the neural system necessitates two pre-existing ‘infrastructures’ – a neural one and a social one. The neural one provides opportunities for the individual to develop neural abilities, but these opportunities are constrained and enabled by the social one. Every action changes both infrastructures, albeit on different timescales from millisecond (neural), cultural-historical (social), and evolutionary (neural predispositions).

3.5 On inclusion of brain components in mental functional systems

The purpose of this stepping stone is to indicate how functions of individual brain components relate to functional systems as conceived by Luria, Vygotsky, and other scholars [9, 14, 15]. In order to illustrate this we may consider the basal ganglia and its sub-components [6, pp. 86-87] (see Fig. 3):

Fig. 3. The basal ganglia, major sub-components, and important functions (from [6, p. 86]; reproduced with permission).

For example, the function ‘goal-directed action’ is associated in Fig. 3 with the caudate nucleus sub-component. However, the caudate nucleus is not realizing this function on its own. Rather, ‘goal-directed action’ needs to be considered as a *functional system* [14], possibly structured as in Fig. 2. From this model, we may conclude that several sub-components of the basal ganglia, besides the caudate nucleus, are involved in ‘goal-directed action’; such as the subthalamic nucleus (action selection); the substantia nigra (motor planning); the globus pallidus (movement); and the putamen (motor skills, learning). We can also see that the same component may contribute to several functions in the functional system, e.g. the putamen. As a consequence, explanative theoretical knowledge about functions of individual components needs to be complemented by functional system models in order to fully specify functions of neural components.

4 IS implications

4.1 *Information* is intrinsically related to the individual abilities for acting

According to Boland, the essence of information is revealed in its name: “Information is an inward-forming” [20]. This view complies well with the neurobiological approach. In the stage ‘afferent synthesis’ (see Fig. 1 and Fig. 2), sensations emanating from the environment are integrated into a multisensory percept as a prerequisite for acting. This integration takes place *entirely in the brain*. The result is *informative* for the individual. Since the activity modalities are posited as requisite for action, this means that *information* may be conceptualized as the totality of objectivating, contextualizing, spatializing, temporalizing, stabilizing, and transitional information. Conse-

quently, action is alleviated if the environment is congruent with these modalities, which implies that we strive to construct our environment accordingly. So, for example, we have maps alleviating spatialization, clock alleviating temporalization, and so on.

4.2 System is comprised of individual neural abilities and the IT artifact

Paul has suggested defining Information Systems as “Information Technology in Use” [21, p. 379]. Since we have posited that information is inherently individual, Paul’s definition indicates that the *system* can be seen as the entity made up by the individual user in interaction with the IT artifact. The development of such a system is manifested as neurobiological abilities in the individual, and most certainly as an adaption of the IT artifact to suit the needs of the social context such as an organization. In principle, this means that we need to conceptualize *Information System* as having both an idiosyncratic, individual facet, and a communal, social facet.

This conceptualization of the IS makes it possible to address several outstanding IS issues from a new vantage point. For example, the IT artifact is seen as a regular physical artifact based on technology, which means that we “do not need to put humans inside the boundary of the IT artifact in order to make these artifacts social” [22, p. 94]. The specificity of the IT artifact lies in its designation to support the integration of information and subsequent action in *all dimensions given by the activity modalities*. Further, the definition of IS as a dialectical unity of the individual and IT artifact enables a clear ontological separation of them, while still maintaining their inescapable, mutual constitution. This is in stark contrast to the ontological foundation of the prevalent IS research stream of sociomateriality, which claims that any “distinction of humans and technologies is analytical only” [23, p. 456].

5 Concluding discussion

IS research progressing from the current foundation of the IS field is unable to address long-standing, die-hard issues, such as the nature of the IT artifact and the IS [4], the question about ‘materiality’ [24], and the status of the IS discipline [1]. This paper proposes to investigate such issues from a new foundation for the IS field, based on a neurobiological perspective. Needless to say, results achieved so far are in a nascent state; a kind of *prescience* “discerning or anticipating what we need to know and, equally important, of influencing the intellectual framing and dialogue about what we need to know” [24, p. 13]. To advance this state, a comprehensive research initiative is called for. As an established IS sub-discipline, the NeuroIS initiative is in a unique position to pilot such an initiative, thus opening up qualitatively new avenues for IS research. With the availability of committed NeuroIS scholars and access to NeuroIS methods and tools [6], the time is ripe to engage this stock of knowledge in an urgently needed revitalization of the IS field.

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