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Team Cognition and Interaction Analysis in Organizations: Insights from Memristor Metaphor

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Abstract

Computer networks and information systems have long served as rich sources of analogies and metaphors in the study of human cognitive processes and collective information processing. This paper explores how these metaphors have provided valuable insights and led to the development of conceptual constructs such as transactive memory systems, that extend beyond individual cognition to encompass collective intelligence in group settings. Building on this foundation, we introduce the "memristor"—a circuit element that combines memory and resistance, allowing for the creation and storage of various states, akin to mental states—as a novel metaphor to represent an interaction pattern and dimension in human collaborative thinking. The memristor, in its technical sense, involves variable and manipulable resistance, and it is metaphorically used here to characterize the productive role of resistance and dissent in collaborative thought processes. This metaphor informs the development of new interaction categories that are integrated into an expanded Interaction Process Analysis (IPA) scheme. The proposed scheme includes four additional categories for productive dissent: X1 (Accepts criticism), X2 (Self-distancing to discuss disagreement), X3 (Constructive criticism, alternative opinion), and X4 (Questions underlying assumptions). Additionally, the scheme incorporates X5, a category for the counterproductive dismissal of disagreement. The paper discusses the implications of unifying certain categories of dissent and outlines the potential for future empirical validation of the expanded model within this emerging research paradigm.

Keywords: Memristor, collective intelligence, interaction process analysis, team cognition, organizations.

Memristör Metaforu Perspektifi ile Örgütlerde Takım Bilişi ve Etkileşim Analizi

Özet

İnsan bilişsel süreçlerinin ve kolektif bilgi işleme süreçlerinin incelenmesinde bilgisayar ağları ve bilgi sistemleri uzun süredir zengin birer analoji ve metafor kaynağı olarak kullanılmaktadır. Bu makalede, alan yazında bu metaforların bireysel zihnin/bilişin ötesine geçerek grup bağlamında kolektif zekayı kapsayan kavramsal yapıların (işlemsel hafıza sistemleri gibi) geliştirilmesini ve önemli bakış açıları sağladığından hareketle, bellek ve direnci birleştirerek bilgi ve zihinsel durumların depolanmasına olanak tanıyan bir devre elemanı olan "memristör"ü, insan işbirlikçi düşünmesinde bir etkileşim modeli ve boyutu temsil eden yeni bir metafor olarak tanıtıyoruz. Teknik anlamda memristör, değişken ve manipüle edilebilir bir direnç içermektedir. Bu çalışmada metaforik olarak işbirlikçi düşünce süreçlerinde direncin ve muhalefetin üretken rolünü karakterize etmek için kullanılmaktadır. Bu mecaz, genişletilmiş bir Etkileşim Süreci Analizi (IPA) şemasına entegre edilen yeni etkileşim kategorilerinin geliştirilmesine rehberlik etmektedir. Önerilen şema, üretken muhalefet için dört ek kategori içermektedir: X1 (Eleştiriyi kabul eder), X2 (Anlaşmazlığı tartışmak için kendinden uzaklaşma), X3 (Yapıcı eleştiri, alternatif görüş) ve X4 (Varsayımları sorgulama). Ayrıca, şema, görüş ayrılığının görmezden gelerek veya açıkça reddedilmesine dair X5 kategorisini de içermektedir. Makale, bazı muhalefet kategorilerinin mevcut analiz şemalarına entegre edilmesinin sonuçlarını tartışmakta ve bu genişletilmiş modelin gelecekte uygulamalı doğrulama potansiyelini tartışmaya açmaktadır.

Anahtar Kelimeler: Memristör, kolektif zeka, etkileşim süreç analizi, takım bilişi, örgütler.

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Introduction

Computer networks and information systems have served as rich sources of analogies/metaphors, and inspiration in the studies of human individual mental activity, human work groups and teams as information processing systems. For instance, the analogies about the human mind/brain as computers or processors, and the study of memory as long term and short term/working memory with the latter being analogous to random access memory (RAM) in computers. Some analogies use structural technical features of these systems to explain human phenomena (e.g., mind as a processor, human working memory as RAM), while others employ them in a more metaphorical sense based on functional similarities.

In this paper we will first illustrate how these metaphorical uses have provided insights and led to the conceptual constructs beyond individual phenomena, extending to instances of collective intelligence, where a group of people are thinking together for attaining a goal or accomplishing a task. We will then introduce a novel metaphor, the "memristor" as an interaction pattern and dimension of interaction dynamics in human collaborative thinking. Memristor is a mostly experimental and conceptual circuit element with limited real-world implementation in electronics and computer science when compared to transistors and resistors. The main idea is that the memory-creating feature of resistance in memristors can be used metaphorically to characterize the productive function of resistance and dissent in human collaborative thinking and can be used to introduce new interaction categories and incorporate them into existing interaction process analysis (IPA) schemes.

As an example of the first task, illustrating the insights from computer science to study how certain functions of human collective/collaborative action like collective remembering and division of labor in collective memory tasks (transactive memory systems/TMS) can be presented (Wegner, 1985).

Transactive memory is the shared memory of coordinative information, memory that is specialized about what the other members of the group know, the knowledge and information that might be necessary for attaining the common goal. It is called the collective system where individuals in a group encode, store, and retrieve information collectively (Argote, 2015). The information that each member has is different as a requirement of mental division of labor, to cope with the burden of knowing and remembering infinitely many things. This collaborative cognition just goes beyond the current knowledge to involve awareness of where to retrieve new skills, which can boost group learning and performance on various tasks (Austin, 2003). Therefore, mental collaboration depends on "transactions" (communication, interpersonal interactions) between the members of the group, hence the name "transactive memory system". Furthermore, a person's tacit or explicit decision to learn and remember new information may be based on the expectation of such transactions. Thus, transactive memory develops

as a function of a person's beliefs about the knowledge possessed by another person and about the accessibility of that knowledge' (Lewis, 2003). So TMS is a meta-knowledge about what another person knows (similar to the index (directory) of shared content in computer networks), and an understanding of how and when that knowledge can be useful and how it can be retrieved, whenever it is necessary. Within the frame of organizational groups, transactive memory has a very crucial role in enhancing group performance through aneffective information-sharing process (Wegner, 1987). It is very important for predicting group behavior and insight into how groups process and structure knowledge in a cooperative way (Hollingshead, 1998).

The computer network analogy provides us the elements of TMS, registering the new information (directory updating), channeling information to the most relevant member (information allocation), and having a strategy for getting it back (retrieval coordination). Research provides evidence that these same tasks arise and must be undertaken when humans remember collectively. To the degree that human groups do solve these problems, it appears that their group memory structures develop and become capable of memory feats far beyond those that might be accomplished by any individual (Wegner, et. al, 1995).

The studies of human collective information processing usually performed by the so-called I/O (input-output) model, where the initial state and inputs provided to the collectivity (team/group) are measured, and after the task completion, post psycho-metric measurements about the team and the performance assessment are carried out. Studying, observing, and measuring what happens during the task completion instance of information processing is usually orders of magnitude-laborious and multi-dimensional than studying the causal or correlational relations between initial conditions, inputs, and outputs. This research paradigm still produces the majority of current research, meanwhile, it is of course criticized by several scholars and schools of social psychology demanding examination of internal cognitive mechanisms that produce those outputs. This research paradigm is called input-process-output (IPO) model (Mathieu et. al, 2008). It is acknowledged as a theoretical model which is currently used in various fields such as management, health care, construction, team learning and technology adoption (Urbini et al.; Ding, 2023) and underlines the relationship between input elements, processes through which they progress, outputs and outcomes (Gan, 2023). By using this model, researchers can examine the correlations between various variables, analyze the effect of interventions or modifications in processes or foresee the outcomes of specific actions (Guler et al., 2018).

This latter IPO approach to understanding human collective/collaborative action considers the collective cognition not as the information content (like the contents of the organizational memory or contents of mental models of the task in the heads of team members), but rather as the instances of information processing and knowledge creating, i.e. processes of interaction among the members (in short form "not the content but process"). These processes of interaction, i.e. collective information processing, are mostly analyzed concepts and constructs based on digital information processing metaphors, where the notion of information processing itself contains a symbolic representation of the world and manipulation of the representations (symbol manipulation) by the collective.

This systemic feature is characterized as a "division of labor, and can be considered a problem-solving activity, where the recursive division of problems into sub-problems is a property of both organizations and computer programs" (Egidi and Marengo, 2004 in Ulubay, 2022). The research paradigm utilizing the IPO model and focusing on the processes of interactions, coins the name of its main object of inquiry with the term "interactive team cognition" (ITC). ITC considers team cognition an activity, not a property or a product or knowledge content; proposes that team cognition should be measured and studied at the team level, and team cognition is inextricably tied to the context (Cooke et. al, 2013). It also claims that team cognition is an ongoing action that arises out of the relations between the team members and it should be measured at team level to put forward the dynamic feature of the cognitive processes (Cooke et al., 2013). Team cognition is located in the interactions among team members rather than the static properties of their shared knowledge structure. ITC acknowledges team cognition as a team process which is inseparable from the context it emerges, highlighting the importance of con Team member interaction, typically in the form of explicit communication (e.g., e-mail, phone, talking face-to-face), is team cognition.

The major assumption which renders itself as a limitation in these studies is that all this collective information processing, in principle, is considered as purely collaborative actions of the members participating in the common goal and shared interest provided by the team's attainment of the task. Members are envisioned as the gears of a custom-built thinking machine or the organs of an organism with a cohesive goal of survival and adaptation to environment, without any individual agency, internal grouping and conflict of interest with other members, or without any dissent against those so-called shared goals/tasks and the organization itself. Even the simple consideration of varying levels of motivation is a significant departure from this notion of a perfect/pure machine of mental collaboration.

Therefore, in the first place, most of the "team mental model" studies show that perfect alignment and overlap of members' individual mental models about what the task/goal is always an important parameter of the efficiency of collective efforts (Klimoski, & Mohammed, 1994), however, the findings supporting the importance of alignment also indicate that this mental overlap is not the case all the time. Therefore, this problem of (lack of) mental alignment about the common goal is a limiting factor for the collective information processing paradigm. Secondly, in addition to this limitation about the cognitive aspects of team collaboration (cognitive domain); varying levels (or lack) of motivation, perception of conflict of interest of an individual (or a group of individuals) regarding the team's goal/task, or dissent about the structure/role distribution of the team and regarding the division of labor are other domain of factors. These factors, in addition to cognitive limitations, create another group of limiting parameters in the "affective domain", where these factors cause positive or negative attitudes towards the presumed common goals and the supposed team structure. Two outcomes, lack of motivation and dissent can be characterized as two sides of a coin, as causes of conflict in an organizational context.

Considering the real-world limitations, frictions, and energy losses in the context of human collective intelligence, there must be novel points of views and more elaborate metaphors to study work groups and teams as information processing systems, in contrast with the view considering them as merely computational systems that process data and information in a deterministic and mechanical/electronic way, where human members are neutral and deterministic components. This novel approach in this study is not being called due to the dichotomy of rationality vs. irrational and affective/emotional dimensions of human social phenomena, rather, it is suggested that while operating in the cognitive and information processing realm, power, motivational and conflict of interest related cognitive-communicative actions (i.e originating from affective domain) will take place in the form of disagreement, conflicting mental models, dissent and resistance. While there are studies or initiatives to address these issues, the impacts of these are also somewhat limited. In this context, to complement the existing works, the concept of memristor (Medeni, 2022) can be utilized here to represent the state of the team and work groups regarding all these real world cognitive and affective dimensions and limitations of human collective information processing. Accordingly, the main contribution of this study will be presenting this conceptualization not only to characterize the affective/motivational dimensions as limitations but also to introduce its productive and structuring nature in the context of social information processing. Therefore, the conceptualized social information processing, team-level memristor system will still operate in the cognitive domain.

Resistance in the physical/electrical sense both creates heat and entropy, and inefficiency, and can also be used for the calibrating voltage and flow of current by means of circuit elements, namely, resistors. By using the concept of memristor, this dual nature of resistance might metaphorically be employed in the study in real life social information processing and communication scenarios to benefit from environmental-social constraints (like resistance, conflict and dissent) which otherwise would be considered as limitation or boundary conditions. Memristor in its technical sense, a variable and manipulable resistance enable designers of electrical circuits to use these various values of resistance, create and store “states” that resemble mental states or state of a program, when an algorithm is being executed. The term memristor is actually a combination of these two essential characteristics; memristance = memory + resistance, an electronic circuit element, a device, linking charge and electro-magnetic flux (Chua, 1971). Although yet not widely materialized, this memristor device has been proposed as an element of innovative computer architectures, as novel memories and in-memory processing devices hopefully to create more energy-efficient and neuromorphic computers (Bao et. al, 2022).

Transistors work as a “switch” in electrical circuits responding to the presence of a current between its input and output terminals by turning on or off a third terminal, which creates infinite possibilities to implement previously mechanical computational devices electronically, which made relevant 20th and 21st-century technologies possible. In comparison, the transistors, memristors are responding to the incoming current by changing its own resistance by using electrophysical/electrochemical features of (like moving ions or charge carriers within) a material in the memristor circuit element, which alters the

device's conductivity. In more technical terms, memristor is characterized as a relation between the charge and the flux (related to the better-known notion of voltage), that can be generalized to include any class of two-terminal devices (which are called memristive systems) whose resistance depends on the internal state of the system (Ventra et al., 2009)

As Chua discusses the physical realizability of its conceptual circuit element in his seminal 1971 study (p 514),36 years later HP Research and Development Lab implemented the idea by utilizing electrochemical properties within the element to manipulate memristance (Strukov et al., 2008) primarily designed for high-density memory storage and energy-efficient computing. Moreover, (Yener and Kuntman, 2014) and (Yener, Mutlu and Kuntman, 2015) studies also proposed designs of Complementary metal–oxide–semiconductor (CMOS) memristors and memristor-based low-pass filter topology to be utilized in signal processing fields. There are also more recent studies that underline the memristors nonlinear nature and built-in sense of history, forming a pinched hysteresis loop with the implication that the memristor stores no energy (Figure 1). Hysteresis is the notion that underlines a system's dependency on its past state. As the hysteresis curve of a memristor implies, the same voltage can yield different values of current, depending on the internal state, thus the history of the memristor, i.e. the memristor retains a memory of its own past (Hayes, 2011), that could result in certain positive (such as certain data storage in memory drives) or negative (such as energy waste) impact in natural sciences.

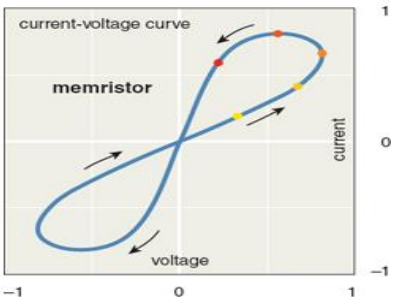

Figure 1. Pinched Hysteresis Loop of Memristor (Adapted from Hayes, 2011)

From an organizational point of view by Clegg, to address the problem of resistance in collaborative settings, in his book Circuits of Power (Clegg, 1989), employs the broader understanding of organizational processes that include power relations between authority and employees, where the notion of resistance as essential to the workings of an organization. Using a different metaphor derived from information science, he classified resistance as episodic and effective resistance in different circuits of power in organizations (overt circuit of power with no need for actual power use, social circuit of power with dispositional power, systemic-economic with facilitative power use).

The above-mentioned hysteresis loop has also been applied to various social science studies. For instance, in economics, hysteresis (originally meaning lagging behind, coming later than) consists of effects that persist after the initial causes giving rise to the effects are

removed; such as retaining high unemployment, even if the policy that had caused it at the first place was ended (Wikipedia, n.d.). Besides rich remnant negative results, positive results such as spontaneous recovery in dynamical networks could also be expected as a result of the hysteresis effect (Majdandzic, A., Podobnik, B., Buldyrev, S. et al., 2014). Meanwhile, Su, Wang, Li, et al. (2017) identify the emergence of the hysteresis loop in social contagions on complex networks. Rios, Rachinskii and Cross (2017) also focus on the institutional level and studies hysteresis arising from social interaction within a firm, benefiting from Ford's (1980) work on structural hysteresis in declining organizations. The authors accordingly propose that the firm may display a form of temporary inertia (in the sense of pay incentives for employee participation), as well as suggest that hysteresis can arise as a result of the social interactions involved, when employees could observe the effort levels of their fellow employees. All these studies, among others, can also signal the significant potential for the memristor (and its pinned hysteresis loop characteristics) application areas in societal interactions. For instance, it could explain the reasons behind certain remnant/extant negative or positive impacts/conditions in organizations and groups as results of myriad social interactions in time.

This elaborate analysis of power and resistance, as well as lag or retainment of positive or negative impact in organizations can be very productively articulated into the study of the problem of boundary conditions and limitations in collective information processing research via the utilization of memristors as a conceptual tool to envision that resistance can be source of memory, change and facilitation of necessary actions in any organizational context. All the critical affective domain-related factors like motivation, adversary, alliance and contextual conflict of interest, can be presented as source of resistance, as it is in a social circuit of power in Clegg's sense. Accordingly, studies could be conducted for whether resistance can be used to 'characterize a problem', 'creating an agenda', where otherwise overt circuit of power will not be aware of, or sometimes deliberately reject to recognize the related factors in the organizational problem-solving and decision-making tasks.

(As another feature of) memristance being both digital and analog at the same time, also increases its use in the human collective intelligence research in order to characterize least quantized phases, and more continuous measures of relations and situations as limiting factors (Ventra et.al 2009). The handling of resistance by a proposed social, team level memristor system is imagined to operate in an accommodating way regarding the dissenting view, disagreement and conflict to find a combination of them with existing team mental models, mental states, which may end up as fusion of ideas, intermediary grounds of compromise, which will be resembling to a notion of expectation space of team cognition states on a continuum (hence analog) rather than, rejection or acceptance (0-or-1) or strict categorical responses.

Principled dissent (Graham, 1986, in Shanipoor and Matt, 2007), in this sense, can be defined/represented in terms of a notion of "organizational memristor", not just as a simple resistance that creates waste energy, or just convert or modulate power. It can turn

into an alternative collective (team) mental model in terms of representing knowledge in a novel way and offering new ways of task-related division of labor and action.

The resistance in the sense of offering new task mental models (TMM), where the resistance blocks a presumed way of working of a team (when things are going in the wrong direction), can then be described a novel pattern of interaction, not a failed interaction or hindrance of a desired interaction. The information shared, processed and created during these moments and instances of dissent, and (seemingly) "moments of dysfunction" could be analyzed as distinct information content and processes, namely interactive team cognition memristors (ITC memristors) or in a higher level, organizational information processing memristors (OIP memristors).

The rest of this conceptual article will elaborate further on these related issues as suggested at this introduction. Accordingly, first categorizations of interactions during team and organizational level cognition will be discussed. Then, studies of conflict, dissent and resistance as a mechanism in collective information processing context will be presented to contribute to the development of the conceptual framework. Finally, a discussion of a unified conceptualization of dissent/resistance as a mechanism such as memristors in collective information processing will be provided before the conclusion.

Categorizations of Interaction during Team and Organizational Level Cognition

As a requirement of the research on human collectivities' putting a collaborative effort on solving problems and making decisions, as well as the IPO paradigm, types of interactions are classified, annotated and analyzed. These classification/categorization annotation schemes are developed for theoretical and methodological purposes in several research disciplines, as in the studies of social psychology/social cognition, organizational behavior and cognitive sciences. In this section, a brief and selective review of these classification schemes will be presented with the purpose of scrutinizing how each of them considered resistant, dissentient interactions as merely having a negative valence, and as time and effort wasting. As a consequence, the exceptions of this approach will be explored. The following review in this section is highly selective, has mere scope of exemplification and does not have any claims of systematically and exhaustively reviewing the relevant fields.

IPA model: Interaction Process Analysis

Interaction process analysis (IPA) is a technique for analyzing interaction in small groups developed by Robert Bales as part of his social psychology research in the 1940s and 1950s (Winter and Ferreira, 1967). This technique aims to examine the relations within groups to perceive how communication, and problem-solving flow during the execution of the group tasks. (Druckman, 2003). It is commonly used in different fields such as family-decision making, therapeutic group settings (Dai et al., 2020). IPA has been effective in putting insight on complexities of group dynamics, for example, negotiations within the group, conflict resolution and decision- making mechanisms and approaches. (Katila and Raudaskoski, 2020). By examining the patterns of interaction within the group, researchers go into the depths of communication cues and emotional

expressions which have the potential to affect group cohesion. Every communicative action of participants of the group is recorded and classified by raters/observers into twelve distinct categories of processes. The unit of observation and categorization is stereotypically verbal or written messages, i.e. utterances, speech acts. The twelve process categories are as follows:

1- Shows solidarity, 2- shows tension release, 3- agrees, 4- gives suggestion, 5- gives opinion, 6- gives orientation, 7- asks for orientation, 8- asks for opinion, 9- asks for suggestion, 10- disagrees, 11- shows tension, 12- shows antagonism.

Bales himself classified these 12 processes into four functional groups such as F1- Socio-emotional positive reaction (1, 2, 3), F2- Task-related information providing (4, 5, 6), F3- Information request and retrieval (7, 8, 9), and F4- Socio-emotional negative reaction (10, 11, 12). Each of the twelve process categories contained in these four functional areas are given in parenthesis (Keyton, 2003). In addition, these functional groups had been grouped into two, as task related (F2, F3) and relational (or "socio-emotional") (F1, F4). Bales, in addition to 12 process categories and 4 functional groups; introduces a third relational dimension to the analysis by specifying paired couples of relevant processes as sequential communicative actions in critical cases of decision, tension management, control, among others. For example, 2-11 for tension management, 12-1 for integration of antagonism, 3-10 for decision. The idea is that orientation happens after certain paired actions are performed by the members of the group, for example asking for orientation and giving orientation (7-6).

Table 1. 12 IPA processes and 4 Functional groups.

IPA Categories	
Socioemotional: Positive Reactions	1.Shows Solidarity/Seems Friendly: Shows positive feelings toward another person
	2.Shows Tension Release /Dramatizes: Reduces the anxiety that a person or group may be experiencing
	3.Agrees: Shows acceptance of what another person has said
Task: Attempted Answers	4.Gives Suggestions: Offers direction/action for how to engage the task
	5.Gives Opinions: Advances a belief or value that is relevant to the task
	6. Gives Orientation/Information: Reports factual observations or experiences
Task: Questions	7.Asks for Orientation/Information: Requests factual observations or experiences
	8.Asks for opinions: Requests a belief or value that is relevant to the tasks
	9.Asks for suggestions: Requests direction/action

	for how to engage the task
Socio-emotional: Negative Reactions	10.Disagrees: Shows rejection of what another person has said
	11.Shows Tension: Indicates that a person is experiencing anxiety
	12. Shows Antagonism, Seems Unfriendly: Shows negative feelings toward another person

As can be seen in the list, this classification focuses on scrutinizing expressive actions which are defined as communicating the emotions, intentions, attitudes, more than mere information exchange. Only 4, 5, 8, 9, 10 can be used to classify neutral information exchanges or requests for information. Still this classification of 1, 2, 3, 6, 7, 11 and 12 emphasizes and scrutinizes socio-emotional actions in detail, which can also be reflecting power relations and dissent against power. As can be seen in the example of "agreeing" (3), which looks like opinion sharing, however, this may also be considered as submitting to the skill/experience-based authority of another member or superior person in the ranks.

IPA coding scheme is employed to annotate and categorize all interactions. Subsequently, it is used to analyze the quality of member participation and contributions, which therefore helps the researchers to dive into the dynamics of group interactions, determining patterns, roles and communication patterns which affect the group outcomes (Schütte et al., 2019). This analysis involves examining the rates at which different action categories are produced by each member (i.e., determining how frequently each member engages in various types of actions) and studying how specific sequences of interactions lead to particular group outcomes (i.e. produced ideas, or task performance).

The studies using IPA revealed some interesting results for academic and practical purposes. For example, some members are undertaking the role of task specialist (F2, F3) and some others social specialist (F1, F4) where each member leads the group in one of the two main functional categories of interactions (Colman, 2015).

The IPA scheme registers the moments of resistance with tangible detail and distinct categories, puts all of them under a separate functional group. However, the general understanding of these instances are considered under a light of a quite unsurprisingly negative valence, and as lacking the positive alternative. For example, in the studies that developed coding schemes following the IPA model, the negative valence actions such as "disagreeing" is considered to be lack of agreement, and the ideas that were rejected are coded as non-finalized ideas, only agreed upon and accepted ideas are registered as outcomes. In their 2013 coding scheme study of group creativity, considering rejection as a dead end, Kou and Harvey analyze only accepted ideas in terms of the sequence of the member interactions and among these interactions that created accepted ideas, meanwhile disagreement and rejection actions are not distinguished from positive ones under the blanket code of "idea evaluation" (E). Their findings suggest that

these evaluation actions are found to be mostly following “idea generation” actions (G), or previous evaluation actions (Kou and Harvey, 2013). In conclusion, IPA scheme has proved to be a significant and remarkable tool for researchers to understand the dynamics of group interactions, decision-making processes, conflict-resolving processes within the small groups and shed a light on the complexities of the human behavior. In future studies, it can be handled with the concept of humor-oriented action used in a study by Medeni et al., 2019).

The Advanced Interaction Analysis for Teams (act4teams) Coding Scheme

Advanced Interaction Analysis for Teams (act4teams) Coding Scheme is an encompassive tool to examine the group interactions in numerous contexts. It is utilized in various fields such as collaborative learning, aviation and organizational meetings. This coding scheme is specialized on analyzing the activity of teams especially on the tasks of decision making, debating different ideas and finding solutions. Although the categorization terminology overlaps with the IPA protocol in-case of “socio-emotional statements", the rest of the categories and the depth of the subcategories and their level of detail, as well as the granularity of the scheme is totally different as summarized in Table 2 by Kauffeld et. al. 2018. For example, the task related actions (“statements" in act4teams jargon) have 3 major higher levels of “problem focused”, “procedural” and “action oriented” which is a result of theoretical underpinnings of later developments in organizational behavior and team dynamics studies. These studies scrutinize task-related actions and distinguish some of them as not directly regarding to the attainment of the task, but about how the team should organize itself to perform these actions. For example, actions related to managing role distribution, division of labor, goal orientation, time and priority management are team-related actions or team-work, in comparison to the actions directly to carry out the task which are called task-work (Fisher, 2014).

As a result, all of the task-related actions in IPA are incorporated in the “problem focused” section in this novel analysis. There are additional “11 fine-grained behavioral categories”, in this category (Kauffeld and Lehmann-Willenbrock, 2012). The team-work related behavioral categories are under the higher category label “procedural” with 9 positive procedural team-related actions, and 2 negative actions. Action-oriented statements are the statements, communicative actions of the individuals about their own contribution and participation during the team collaboration, which are, hence, different from team-work, procedural actions. Since all other three higher categories of this scheme are all about actions, this last label is somewhat misleading or confusing until the detailed definition is read, which reveals that action-oriented statements are about attitudes, intentions and evaluations about taking or not taking action, but not communicative actions themselves contributing to team-work or task-work.

Table 2. Act4teams coding scheme for coding group interactions (Kauffeld et.al, 2018)

Problem-focused statements	**Procedural statements**	**Socio-emotional statements**	**Action-oriented statements**

Problem	**Positive**	**Positive**	**Positive, proactive**
Describing a problem	Goal orientation	Encouraging participation	Expressing positivity
Connections with problems	Clarifying	Providing support	Taking responsibility
Defining the objective	Procedural suggestion	Active listening	Action planning
	Procedural question		
Solution	Prioritizing	Reasoned disagreement	**Negative, counterproductive**
Describing a solution	Time management	Giving feedback	No interest in change
Problem with a solution	Task distribution	Humor	Complaining
	Visualization		Seeking someone to blame
Arguing for a solution	Summarizing	Separating opinions from facts	Denying responsibility
Organizational knowledge	**Negative**	Expressing feelings	Empty talk
Knowing who question	Losing the train of thought	Offering praise	Ending the discussion early
	(running off topic)	**Negative**	
		Criticizing/backbiting	
		Interrupting	
		Side-conversations	
		Self-promotion	

Interestingly, including the socio-emotional, the task and teamwork related ones, there is a focus on negative or disruptive action categories in detail, similar to what IPA also emphasized. However, as it can be seen from the labels of behavior categories of negative valence, they are not considered as actions with their own objectives, reasons and outcomes, but characterized as the absence of positive behavior and/or outright harm intended sabotage like behavior; or at least, lack of engagement. Even this "advanced interaction analysis for teams" scheme has a different ontology, a higher granularity, and historically and theoretically different underpinnings than IPA; a specific characterization of resistance, objection and dissent in group interactions is similarly missing.

Studies of Conflict, Dissent and Resistance as a Mechanism in Collective Information Processing Context

Even if we could not find in interaction analysis ontologies (coding/categorization schemes) of IPO paradigm that are reviewed in this study, there are studies in

organizational behavior and industrial psychology, where instances of disagreement, counter arguments and dissent are distinctly specified and categorized to examine their effect on collective information processing without an initial assumption of an obstructive effect of these actions. For instance, Schulz-Hardt et.al, in their 2006 study, focused on group decision making in hidden profile task situations. In hidden profile task-based experimental scenarios or real world observations, each member has partial information about the task and solution (which impedes them to find the best solution) that nudges them to choose a sub-optimal solution. Among other members in the same situation with different kind of partial information and beliefs of fitness about another sub-optimal solution to be the best solution, a conflict is expected to arise by design of the experiment or real world context. The Schulz-Hardt 2006 study postulates and empirically confirms that, the conflict between the two or more opposing solution factions should stimulate the exchange of information and, hence, the solution of the hidden profile, sometimes the discovery of the optimal solution which was not available to any group of the members. Their study isolates these instances of conflict as "prediscussion dissent" and characterizes as a facilitator for decision quality (Schulz-Hardt et.al, 2006).

Another school of research develops the notion of "heedful interrelating", emphasizes thoughtfulness (heed), empathy and attention to other members' perspectives and mental models during communication and collaboration to ensure their well-being and effective collaboration. Involvement in heedful interrelating is enabling the individuals to develop a common model in the group, fostering an enriched understanding of the importance of mindful interactions for both individual growth and collective success (Daniel and Jordan, 2015; Mammen, 2024). Karl Weick's seminal 1993 research "Collective Mind in Organizations: Heedful Interrelating on Flight Decks" tries to detect and analyze these patterns of heedful interrelating, when each action in the context of joint action contains an understanding of the mental model of the perspective of the other party. Existence of this element is as Weick and Roberts suggest, "as close to a physical substrate for the collective mind, as we are likely to find. There is nothing mystical about all this. Collective mind is a kind of manifest, when individuals construct mutually shared fields. This shared field is the demonstration of the collective intelligence and cognitive capacity of the group in which people contribute to the enactment of the collective mind (Erkelens et al., 2015; Orme- Johnson et al., 2022). The collective mind related with the terms of collective consciousness and unconscious as suggested by Carl Jung, at this point shared memories and universal symbols support social evolution. The collective consciousness is shown cross-culturally with symbols and archetypes affecting human thought and behavior (Addas and Pinsonneault, 2010). It is both a cognitive phenomenon and concrete expression of culture (Hussain and Joshi, 2016). The collective mind that emerges during the interrelating of an activity system is the more developed and more capable of intelligent action the more heedfully that interrelating is done" (Weick and Roberts, 1993). This distinct structure and feature of interrelatedness becomes the intermediary tool by which collective mind is evident (Fitch and Adams, 2006). The collective mind is not the only whole of personal knowledge but it is structure of

interrelated activities among various people, highlighting the significance of heedful interrelating in forming the nature and scope of collective cognition within a group (Maitlis, 2005; Yoo and Kanawattanachai, 2001). The interesting part is that, while all series of thoughtful and emphatic actions comprise the core of the theory - on the other hand - subordination to the other party's disagreement when necessary, is a core part of heedfulness, regardless of the authority position of the dissenter. This is also characterized in relation with the notion of self-distanciation, which is "individuals taking distance from their customary and unreflective ways of acting" (Tsoukas, 2009) and the process in which individuals detaching themselves from their opinions, ideas and emotions during group collaboration (Tsoukas, 2009); when a dissenting opinion makes sense and time to change the opinions of one party comes, in favor of the dissenting party. Self-distanciation during mental collaboration is considered not only a cognitive skill because of its effect on positive and constructive production, but also as a very critical affective attitude. It can help to create new perspectives and develop new understandings. Self-distanciation has a very significant role in fostering the individuals to participate in collaborative decision-making process. Individuals can make informed selections, decisions (Kates et al., 2018).

In conclusion, nevertheless, as the interaction analysis studies and some exceptional IPO paradigm research suggests, for the sake of being effective, and adaptive, the actions of disagreement, rejecting the current agenda or offering a new one should be pre-defined as a mechanism. The next section, accordingly, will suggest a unified conceptualization of dissent and resistance, benefiting from the memristors, for collective information processing.

Discussion: A Unified Conceptualization of Dissent/Resistance as a Mechanism: Memristors in Collective Information Processing

In this study until this point, the lack of analysis of dissent and/or resistance as a mechanism has been surveyed through different fashions of studies of collective information processing. As stated at the beginning; using information/computer science related metaphors has provided a rich understanding of collective remembering as in the example of developing the concept of transactive memory systems. To understand the resistance and dissent as a mechanism in the workings of human teams, as an element of team cognition systems, we have proposed the use of the analogy or metaphor of the "memristor", the idea of a device creating a computational "state" or memory, out of current and magnetic flux interacting with a resistance, in electronic circuits. This metaphorical device or system in our context will have an information processing function in the instances of dissent and resistance.

What is Interactive Team Cognition (ITC) Memristor System to be Observed, Measured and Evaluated as Interaction?

In the conceptualization of the study, ITC Memristor is not conceived as the resisting agent (individual agent, or a group, division, among others), but the system that registers, responds to, and remembers the resistance, therefore memristance does not

emerge as the acts of resistance and dissent but, as the interaction of the collective, the team cognition system, with these instances of dissent (hence Interactive Team Cognition Memristor System - ITCMS).

In the context of a resistance or dissent, it's shown from the current and past research literature that, trying to overcome, block or suppress these kinds of interactions and characterize them as resource-wasting obstructions might be counter-productive and backfiring, and the correct handling and utilization of these instances could serve more to the goals of the teams and organizations. Therefore, the notion of memristor will be conceptualized as "specific interaction patterns to handle and register the instances of resistance/dissent in the most productive way". In a team interaction context, with respect to the dissent and disagreement regarding a piece of information or a preference of a possible future collective action (decision), the teams equipped with this specific interaction pattern would recognize, register and process the dissent to inquire its potential of filling any gaps in the possibly partial knowledge of the team for that instance, task and context. The teams may also register this as a sign of a problem to address immediately or later to change anything about the team's structure and composition.

The following preliminary coding scheme (Table 3) is a proposed, expanded version of the IPA model, the Interaction Process Analysis (Bayes, 1950) enhanced with four additional ITC Memristor System (ITMS) categories and one detrimental category with a negative valence in relation to ITCMS actions. These X1, X2, X3 and X4 are categories of the productive/creative dissent or resistance interactions. The critical discussion beyond the scope of this conceptual paper is whether the interaction type 12 ("disagrees") and X5 the counterproductive blanket rejection of disagreement and disagreement in general, can be united into one category. This will be left to further steps and next studies of this research paradigm and most probably resolved by empirical use and evaluation of the reliability and construct validity of a proposed expanded mode

Table 3. Expanded Interaction Coding Scheme utilizing Memristor Metaphor

F1 Positive socio-emotional reactions	Shows solidarity Shows tension release Agrees ***X1- Accepts criticism*** ***X2- self-distanciation to discuss disagreement***
F2 Attempted answers (Task-work)	Gives suggestion Gives opinion Gives information ***X3- Constructive criticism, alternative opinion***
F3 Questions (Information request and retrieval)	Asks for information Asks for opinion Asks for suggestion ***X4- Questions underlying assumptions***
F4 Socio-emotional negative reaction	Shows antagonism Shows tension

	Disagrees ***X5- Dismisses disagreement***
ITC Memristor System Actions: X1, X2, X3, X4. X5 will be evaluated as detrimental to ITCMS.	

Therefore, the steps to detect the activation of ITC memristor system can be presented as follows:

Utilize the coding scheme and register the dissent-disagreement-rejection-resistance.

Inquire whether any specific interaction pattern is activated as a procession of this instance of dissent. For example, are there any direct interactions addressing the dissent leading to the changes in the course of flow of collective thinking or communication? Is the information content provided during the dissent-induced discussion included in the team's later iterations of representation of the task or problem? If yes, we can say that this team has activated a task-work related ITC memristor. The change in the course of instances of team interaction, as a result of this resistance, has created a new course of action and a newer state of team cognition. Here we can claim metaphorically that the ITC memristor registered a computational state, and if this experience was significant enough, it is encoded and stored in the transactive memory of the system (TMS) as a more permanent memory.

If the handling of the resistance and dissent by another specific interaction pattern specifies the disagreement being more pertaining to the structure and working of the team, the changes in the organization, and role definitions and role distributions should be inquired. An observed change on any of these after the dissent-resistance is registered, it can be claimed that team-work related ITC memristors were operational (team-work ITC memristor vs. task-work ITC memristor).

In the practical utilization sense of Expanded IPA, these three steps comprise of searching for X1 and X2s as responses to X3s and X4s. In response to X3s and X4s, detection of X5 (dismissal of resistance) distinct from F4-12 (basic disagreement) will enable evaluators to analyze the interaction patterns as indicators of the absence or malfunctioning ITMS. Similar to analysis of specific pairs of consecutive actions as specific process in the IPA tradition, in the above Expanded IPA, the pairs of X3-X1, X3-X2, X4-X1 and X4-X2 as processes of ITMS, namely as instances of productive and creative resistance and dissent.

Additionally, the below inquiries could also be utilized: What are these specific patterns of interactions that will be crystallized as ITC memristors, what are their features?

In the studies mentioned in the previous sections, some of the specific patterns of interactions presented above that define and construct ITS memristors, are already studied

as competencies of teams and team members that they employ, when they are presented to a conflicting view, an objection, complaint, or resistance. They are the actions and suspension/activation/updating of current mental models to accommodate and process the mental models, i.e. the point of view of the dissenter. Tsoukas defines (2009) this suspension, in relation to his notion of self-distanciation; to provide a window for an update in own beliefs, as follows: "Relational engagement is created by what Möllering (2006, pp. 110–111) calls "suspension," namely, the attitude that enables participants to suspend 'irreducible social vulnerability and uncertainty, as if they were favorably resolved', which is the basically not trying to overcome or ignore the resistance but 'maintain a state of favorable expectation toward the other' and accommodating it into the process and mental models of the party experiencing the dissent (Tsoukas, 2009). This self-distanciation attitude against conflict is inspired from the heedful interrelation notion of Weick (1993), as presented in the previous section.

Heedfully interrelated teams and organizations, efficient work groups are already handling dissent-resistance as part of interactive team cognition process. Beyond this, the proposed metaphor or construct of ITC memristor endows the researchers with the power of abstraction and simplification in the sea of multiplicity of interactions with multiple functions, intentions and meanings. As a perspective, the ITC memristor construct can enable the researchers to inquire about these specific instances of information processing, productive and structuring instances of dissent-resistance in organizations and teams. If the inquiry detects a systematic response and accommodation to the dissent and resistance, the detection of ITC memristor will have an explanatory power for efficient information processing teams in contrast to the resistance ignoring, avoiding, preventing, deflecting teams, where those instances of dissent and resistance are considered as costs hindering the performance and efficiency. If the memristor kind of interactions do exist, but go unnoticed because of the shortcomings of our coding system where every dissent-resistance is categorized as the lack of productive participation or obstruction; some very important dynamics and probably positive outcomes of team interaction will go undetected and incorrectly analyzed. This means that those specific ITC-memristor utilizations and activations can and should be integrated into a novel interaction analysis coding scheme.

Conclusion

In this study, a new notion of memristors has been suggested in order to address dissent and resistance for collective information processing. As a new proposition, there are still issues to be identified and explored further, for instance distinguishing group and organizational level interactions. Further suggestions could also be provided in order to test this memristor construct as a part of experimental/observational study. Still it is hoped that the suggested ideas could be useful for new studies elsewhere. Moreover, the (pinned) hysteresis loops could provide a reflective and refractive lens through which to understand the complex, nonlinear nature of organizational and human behavior and decision-making processes, addressing issues such as sustaining adaptability and resource

optimization, among others, as for future research directions, as used in a study by Medeni and Medeni (2012).

As presented in the previous explanation (step-2) in section 4.1, using the notion/metaphor of memristor, and creating memory and team mental state out of resistance; can be articulated into another group of computer networks related to transactive memory systems. The internal consistency of computational metaphors, in explaining information processing systems, combined with the versatile compatibility (from memristor to long term TMS memory), allows for their seamless integration. This integration can provide additional levels of abstraction and simplification, empowering researchers in the field of team cognition systems to develop further novel conceptualizations of otherwise imperceptible phenomena. Integration of computational metaphors can enable the research community to benefit from the spill-over effect of new conceptualizations triggering others and create a semantically and conceptually integrated ontology of the field.

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