

# Chapter 2

## Improvisation as Model for Real-Time Decision Making

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**Abstract** This work explores the concept of improvisation as a framework for understanding real-time dynamic decision making (RTDDM) and systems support for it. The contexts for RTDDM and those in which agents improvise are remarkably similar according to several parameters. The foundations of improvisation are built on management theory, practice, and education. The work provides a rich definition of improvisation and a typology of different improvisational contexts based on two key dimensions. This framework illustrates how seemingly diverse contexts such as emergency management and jazz performance are related. The work then explores the antecedents of improvisation, degrees of improvisation, the elements for individual and team improvisation, and effective improvisation. The work then explores the design of Real-Time dynamic decision support systems (DSS). These are broken into pre- and postperformance support, as well as Real-Time support. The conclusion is that our knowledge of improvisational contexts can shed new light on RTDDM systems design and development.

**Keywords** Real-time dynamic decision making • Improvisation • Jazz • Decision support systems

### 1 Introduction and Research Objectives

The purpose of this research is to apply emerging models of organisational improvisation to better understand Real-Time decision making and explore the implications for the design of decision support systems (DSS). Real time in this case is defined as decisions that must be made within seconds or minutes. As will be shown, improvisation

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and Real-Time decision making are inter-related concepts and contexts. Improvisation has often been likened to a “conversation.” This distinction has implications for the design of DSS to support Real-Time decision making in context. Unlike systems that deliver pre-planned routines, knowledge and scripts, helping decision makers to respond to situations in real time by engaging in improvisational behaviours and “conversations” requires different design principles and information systems with different features. Systems must deliver Real-Time information and knowledge to decision makers to support a range of problem-solving behaviours. Our goal is to flesh out these specifications by looking at this problem from the vantage point of the literature on improvisation.

There are several objectives to this work. Specifically:

- To discuss the real-time dynamic decision making (RTDDM) support context and the relationship of improvisation to RTDDM,
- To discuss the history of research in organisational and team improvisation and the definition of improvisation,
- To introduce a framework that classifies improvisational contexts according to problem structure and magnitude of consequences (MoC),
- To discuss the antecedents of improvisational behaviours and degrees of improvisation,
- To define the concept of performance,
- To identify the elements necessary for effective individual and team improvisation, and
- To flesh out the unique design requirements necessary to support improvisational behaviors and conversations.

I begin with a discussion of the relationship between Real-Time decision making and improvisation, and then discuss the elements of improvisation in greater depth.

## **2 Real-Time Dynamic Decision Making Contexts and the Relationship with Improvisation**

The literature (e.g., Lerch and Harter 2001; referencing Brehmer 1990, 1992; Edwards 1962) suggests that four primary factors define RTDDM contexts:

- Tasks require a series of decisions,
- Decisions are interdependent,
- The environment changes autonomously and as a result of the decisions taken by members, and
- Decisions are made in real time.

Let us contextualise these parameters in the context of a fighter pilot engaged in evasive action as he or she makes decisions regarding the flight path of the aircraft. To begin with, the task environment requires a series of decisions, many of which have been pre-programmed. These decisions are interdependent, i.e., each choice leads to other choices processing down a decision tree. As decisions are selected, the hostile craft may change direction in response, thus changing the texture of the environment.

The pilot (along with the on-board computer systems) makes decisions in real time, i.e., in the fraction of a second. As can be seen, all conditions for RTDDM are met in this context.

Interestingly enough, we do not typically think of the pilot as improvising. We describe the evasion in terms of procedures and “expertise.” Yet, the pilot must modify the “script” to respond to Real-Time changes in the environment. It can be shown that improvisation and Real-Time decision making are inter-related constructs, and that improvisational contexts meet the requirements proposed above.

Let us take another example that clearly is an improvisational context: a jazz group. Jazz musicians begin together and end together, but in between, they modify the key parameters that define the “song” (e.g., melody, harmony, rhythm); in short, they improvise. Is a jazz performance a case of RTDDM? Table 1 clearly indicates that this is the case, going by an application of the criteria proposed by Lerch and Harter (2001).

As can be seen above, all the criteria are met. Jazz musicians execute choices in real time in the fraction of a second during a solo performance. The choice of notes and rhythms influences and is influenced by the other members of the group. Interestingly, the quality of the performance is determined by elements that are recognisable by the audience interspersed with elements that are surprising or unpredictable. Although it may not seem so to someone new to the art form, the experimentation that occurs during performance is not random but is based on underlying patterns and themes that are a part of the immediate context as well as the broader context of jazz music (we will discuss this issue in greater depth in the next section). One difference, however, between jazz contexts and other Real-Time contexts (e.g., emergency management) is that environmental changes during a jazz performance are almost always internal (e.g., actions taken by the performers) and rarely external (e.g., a failed microphone, an earthquake). During emergency management situations on the other hand, external changes in the environment (i.e., events) are frequent and expected.

Furthermore, as an instance of RTDDM, jazz can be further described in terms of the task framework provided by Lerch and Harter (2001). They argue that RTDDM contexts can be characterised in terms of the clarity of the goals, task

**Table 1** Improvisation as an instance of RTDDM

RTDDM	Improvisation - jazz example
Tasks require a series of decisions	Yes. Team must decide what tune to play, its style, the tempo, the order of soloing, etc.
Decisions are inter-dependent	Yes. As each player performs, he or she is influenced by the choice of notes (courses of action) by other players
The environment changes autonomously and as a result of the decisions made by members	Yes. Each player can interject new musical events at any time during performance, forcing the other players to respond (internal change)
Decisions are made in real time	Yes. Each performance is completed within minutes. At a tempo of 120 beat/min., notes are chosen at the rate of 0.125–0.5/s

**Table 2** RTDDM task parameters applied to jazz context

RTDDM task parameter	Improvisation - jazz example
Clarity of goal	Goal is clear: produce a quality performance. Measures of success include audience/client feedback, communication between members, error detection/correction during or after performance.
Structure of task	Task is structured by referent and norms of performance mitigated by familiarity of members with each other and experience in task.
Task complexity	Complexity is variable depending on underlying referent and experience of players. Causal relationships are fairly well understood by experienced members.
Level of uncertainty	Uncertainty is a function of the experience of the members, familiarity, training, availability of referents (e.g., SOPs), and audience.
Time pressure	Notes are typically chosen at the rate of 0.125–0.5/s and even faster in some cases.

structure, task complexity, level of uncertainty, and time pressure. Table 2 elaborates the Real-Time decision-making aspects of a jazz performance in terms of this framework.

The conclusion we can draw from the preceding framework suggests that improvisation is an instance of RTDDM. In keeping with the alignment of these contexts, the goal of this chapter is to re-interpret RTDDM in light of the rich body of knowledge that has emerged regarding the concept of improvisation. Put another way, we can use the rich descriptions of improvisation and improvisational contexts (e.g., jazz performances; emergency management situations) to obtain new insights into RTDDM and how to design systems support for it.

In the next section, we discuss the nature of improvisation in greater detail.

### 3 Towards a Shared Understanding of Improvisation

#### 3.1 History of Interest in Improvisation

Despite the appeal of Peter Drucker’s (1985) view of the organisation as a “symphony” and leaders as “conductors,” there has emerged a sense that organisations rarely follow the “score.” Organisations sometimes operate as places of rationality, scripts, and routines, but this is not true in every context. They frequently improvise to manage and capitalise on changing conditions and needs. As environmental complexity (i.e., multiple stakeholders) and the velocity of change have increased (Huber 1984), interest in improvisation has grown.

We see the penetration of the concept of improvisation in several areas of the management literature including management theory, management practice, and education (see Fig. 1).



**Fig. 1** Emphasis of improvisation in the management literature

A major milestone for research in organisational improvisation occurred at the Academy of Management (AoM) meeting held in 1995 in Vancouver. A special event was organised by Hatch, Barrett, and Havlovic of the AoM 1995 LAC to explore the use of jazz as a metaphor for understanding organisation and improvisation. The interest generated at this meeting motivated several research studies which, in 1998, resulted in a special issue of *Organization Science* devoted to organisational improvisation. Since then, a stream of articles has poured into the literature on issues ranging from organisation to product innovation to systems design, e.g., Zack (2000), Kamoche and Miguel Pina e Cunha (2001), McKnight and Bontis (2002), and Morazzoni (2005) to name a few.

### 3.2 Defining Improvisation

Some common definitions of improvisation include:

- To invent, compose, or perform something extemporaneously,
- To improvise music, and
- To make do with whatever materials are at hand.

The roots of the idea come from the Latin derivative “proviso” which means to stipulate beforehand or to foresee. “Im” means “not”, i.e., the negation. Hence, the word *improvisation* can be interpreted to mean *unforeseen* or to take action in the moment.

This notion dovetails with the ideas of Real-Time decision making and making decisions “on the move” and fits nicely with the theme of this book. Quoting Berliner, Weick writes:

Improvisation involves reworking pre-composed material and designs in relation to unanticipated ideas conceived shaped and transformed under the special conditions of performance, thereby adding unique features to every creation

Berliner (1994, p. 241)

Or, put another way by Barrett (1998): “Improvisation involves exploring, continual experimenting, tinkering with possibilities without knowing where one’s queries will lead or how action will unfold” (p. 606).

Furthermore, the sometimes mistaken notion that during improvisation, the decision maker simply makes things up in the moment without rigor or structure is inaccurate; many would argue that nothing could be further from the truth:

The popular definitions of improvisation that emphasise only its spontaneous, intuitive nature...are astonishingly incomplete. This simplistic understanding belies the discipline and experience on which improvisers depend, and it obscures the actual practices and processes that engage them. Improvisation depends... on thinkers having absorbed a broad base of... knowledge, including myriad conventions that contribute to formulating ideas logically, cogently, and expressively.

Berliner (1994, p. 492 cited by Weick)

In order to be able to respond effectively in context, the improviser must have at his or her disposal sets of routines and packets of knowledge that roughly match that context. In other words, “you can’t improvise on nothing; you got to improvise on something” (C. Mingus appearing in Kernfeld 1995, p. 119 as cited by Weick 1998). A decision is made then to modify the routines to fit the novel conditions that exist for a given situation.

Making effective decisions in real time requires the decision maker (DM) to make sense of what is being communicated by others straight off and to self-reflect (or hear) the words and behaviors of the DM himself or herself. Weick refers to this as retrospective sense making. The latter requires the ability to self-monitor and listen to one’s own voice. It also requires extensive memory to assess resources and make choices. “If you are not affected and influenced by your own notes [or ideas] when you improvise then you’re missing the whole point” (Konitz, cited in Berliner 1994, p. 193 as cited by Weick 1998).

Finally, improvisation is *process oriented* as opposed to *output oriented*. This distinction is made clear by comparing improvisation to innovation. Although Drucker defines innovation as change that results in new levels of performance (1985), he is referring to the outputs of such change (e.g., the creation of goods or services) rather than to the performance itself. Luecke and Katz (2003, p. 2) clarify this idea of innovation: “Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services.” Improvisation, on the other hand, focuses on the quality of the performance of the agents (and the resultant outcomes) as opposed to the artifacts that they may use or create.

3.3    *A Typology of Improvisational Contexts*

We see examples of improvisation in many different fields ranging from music to business to medicine. In Table 3, we outline several areas of activity aligned with improvisation. We contrast this with *design* or *composition*. The latter are non-Real-Time decision-making contexts that result in the creation of ideas, activities, and artifacts. Design and improvisation are related by output but differentiated by process.

There are many types of improvisational contexts as illustrated above. We can differentiate contexts by classifying them according to one or more underlying dimensions. Such classification can be done from a variety of perspectives; however, I have chosen two dimensions that provide a useful first cut at delineating the various seemingly disparate types of improvisation. Again, this classification is a starting point, and further subdivision will be the subject of future research.

The two dimensions identified for the initial typology are: (a) the degree of structure of the problem space and (b) the degree of risk of actions taken, where risk is defined as the likelihood of outcomes that bear consequences for direct recipients and other stakeholders. For example, in jazz, the recipient is the listener. In health care, the recipient is the patient and his or her family.

Simon (1960) defined the degree of structure of the problem space (e.g., structured to unstructured) to evaluate different problem-solving contexts, a framework that was subsequently used by Gorry and Morton (1971) to categorise DSS. Structure in this case refers to the degree to which the problem-solving domain can be conceptualised and the procedures, methods, and decision aids that can be developed to support the decision maker. For example, frequently performed surgical procedures tend to become structured problem spaces over time as the surgery is refined and standards evolve. On the other hand, administering an experimental new drug is considered a low-structure context as limited experiential knowledge is available to the decision makers.

The second dimension, outcome risk, is referred to as the MoC by theorists in the study of business ethics. MoC is a component of moral intensity as defined by

**Table 3**    Areas recognised for improvisation

Area	Sub-area	Design (Composition)	Improvisational Behaviours
Performing arts	Music	Classical	Jazz music
	Theatre	Opera	Improve theatre
	Dance	Ballet	Jazz dance
	Comedy	Comedy shows	Improve comedy
Visual arts	Art	Finished works of art	Doing art studies, sketches
Literary arts		Novels, poems, essays	Telling stories
Engineering		Buildings, products	Building models
Management		New product development, e.g., iPod	Responding to crisis, e.g., Tylenol; problem solving
Medicine		Routine surgical procedures or protocols	“Unexpected” and complex surgeries

**Table 4** Typology of improvisational contexts

Structure	Hi	High structure/low risk	High structure/high risk
		Examples: Traditional jazz music Business simulations	Examples: Surgical procedures Military operations
	Lo	Low structure/low risk	Low structure/high risk
		Examples: “Free” jazz music Free form brainstorming	Examples: Emergency management Fixing the world financial system
	Lo	Hi	
	Magnitude of consequences		

Jones (1991). MoC captures the notion that actions that result in more severe consequences (e.g., death, dismemberment, etc.) are deemed to have higher moral intensity, all other things being equal. MoC is defined as “... the sum of the harms (or benefits) done to victims (or beneficiaries) of the moral act in question” (Jones 1991, p. 374).

Improvisational contexts may be delineated by these two dimensions, thus giving rise to the following typology (see Table 4).

The four quadrants allow us to categorise different improvisational contexts. For example, traditional jazz music is considered a high structure, low-risk context. Traditional jazz (e.g., Dixieland) has a well-defined set of rules and structures that define the music within which the improviser can take liberties. This is contrasted with “free jazz” that minimises most structures for the performer. For the audience, this is the most challenging type of jazz to listen to and requires the most active interpretation and sense making. Both are considered low risk in that the consequences of a poor choice are minimal. While it may result in embarrassment to the performer and some dismay on the part of the listeners, these “damages” are temporary and easily recovered. Other low-risk environments include most forms of the performing arts (although dance could result in physical injury), the visual and literary arts (although inflammatory material can carry civil and criminal penalties), and simulations used in business, engineering, and health care. Lower MoC contexts encourage decision makers to take risks of increasing magnitude and to push the envelope of what is “expected.” We see this occurring in jazz on a frequent basis.

High-risk environments are typical in business, medicine, and engineering practices such as emergency management, crisis management, complex surgical procedures, and logistics. In these cases, poor decisions can result in physical, psychological, and financial harms to one or more stakeholders (Stein and Ahmad 2009). Although some high-risk contexts such as doing complex surgeries or executing a military mission benefit from a fair degree of problem structure, they are nonetheless risky. The biggest problem oftentimes here is the variance in the characteristics of the recipient, e.g., the patient.

High-risk contexts typically constrain decision makers who will be more cautious and attempt to rely on existing routines. This is typical when doing complex surgical procedures. The surgeon and his or her team adhere to well-constructed protocols and routines; deviation is not desirable. This type of improvisation is different,



becoming the “flexible treatment of pre-planned material” (Weick 1998 quoting Berliner 1994, p. 400).

However, in the absence of routines and conditions of high MoC, the decision maker must perform under the most trying conditions and may be forced to take more risks by necessity. Indeed, evidence suggests that some DMs will fail in these contexts, i.e., overcome by the MoC and unable to control feelings of panic, some manage in crises and some do not. Decision makers may be forced to improvise given a deficit of knowledge or experience or both.

3.4   *Antecedents of Improvisation*

There are several antecedent conditions that lead to opportunities for improvisation. These include but are not limited to:

- Unexpected problems,
- New or revised goals,
- Changes in the structure of the problem space,
- Changes in the environment, and
- Knowledge limitations.

Problems that emerge unexpectedly can trigger improvisational behaviors by the agents. The case of Apollo 13 dramatically illustrates the role of antecedent conditions. The explosion in the fuel line of the spacecraft sent the crew and ground support group into a frenzy of improvised problem solving. In Table 5, we see how the values of these factors changed.

At the onset, the explosion imposed severe time constraints on the agents because the lives of the crew depended on swift diagnosis and treatment. The structure of the problem space abruptly changed from “routine” to “novel” because of the unspecified damage to the ship. There were now limited structures or routines available to help the agents. The state of the agents’ knowledge went from relatively complete to incomplete. Agents now found themselves in a turbulent environment (Emery and Trist 1965) of multiple interconnected problems. Goals were quickly revised from mission duties such as research and data collection to survival. Agents thus went from performing a relatively routine set of activities to a mode of improvisation in order to survive. Very quickly, the crew and ground support

**Table 5**   Illustration of the change in antecedent conditions in case of Apollo 13

Condition	Before	After
Unexpected problems	None	Numerous
Structure of the problem space	Well known	Limited structures or routines
New or revised goals	No	Yes
The environment	Stable	Turbulent
Knowledge limitations	Well-articulated base of knowledge	Limited or no knowledge by agents
Constraints	Within range	Time and resource constrains

diagnosed the problem and crafted a strategy to deal with it. In general, they developed new solutions based on existing knowledge and constructed hypotheses on the spot; they had no choice.

Although transitions from high-structure/high-risk situations to low-structure/high-risk contexts rarely occur so dramatically in more down-to-earth settings, there is considerable variation in terms of the degree of improvisation over the course of a performance. In other words, whether the context changes or not, the degree of improvisation is not static and may change over a given time period (i.e., during performance).

In the next section, we discuss degrees of improvisation in response to changes in antecedent conditions as well as throughout a given performance when agents change goals.

### 3.5 *Degrees of Improvisation*

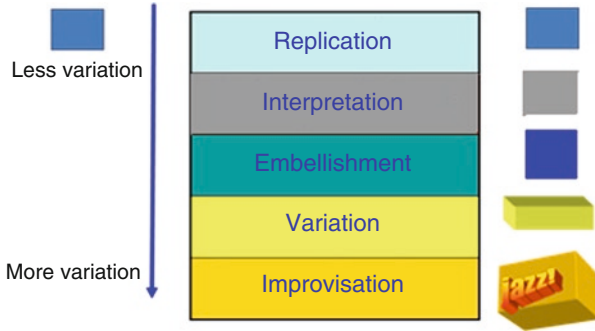
At its simplest level, improvisation is a set of design or problem-solving behaviours that involve the modification of a *referent*. A referent is declarative knowledge, procedural knowledge, a representation or schema that guides and constrains an improviser's choices. For example, a referent can be a score or a set of procedures, routines, or scripts. In business, it can be a standard operating procedure (*SOP*); in medicine, a *protocol*; and in music, a *score*.

To be clear, when we discuss improvisational behaviors, we refer to a set of behavioral types, not a single behavioral type. There is considerable difference between what is referred to as an "improvisation" in one context versus another. Those differences are a consequence of the degree to which the referent is modified by the improviser.

Thus, improvisation can be classified by the amount of variation of the referent. Although these variations properly fall on a continuum, we can discern at least five different categories along that continuum (see Fig. 2):

- Replication (i.e., no improvisation),
- Interpretation,
- Embellishment,
- Variation, and
- Improvisation (i.e., full improvisation).

*Replication* is the opposite of improvisation, i.e., there is no change in the referent. Replication is just a simple copying of the original with all its structural and functional features intact. *Interpretation* involves subtle changes to the referent. This is evidenced by conductors who interpret a work by Bach or Mozart. The score or "instruction set" is given and meant to be replicated but with slight stylistic changes by the orchestra leader, thus giving rise to a characteristic sound of a particular orchestra, e.g., the Philadelphia Orchestra under Eugene Ormandy. *Embellishment* is an active and purposive act of changing the referent, but within well-defined



**Fig. 2** Degrees of improvisation

boundaries imposed by the genre. Embellishments typically enhance the major qualities of the referent by reinforcing them and accentuating them, rather than diminishing them. A cartoonist or storyteller embellishes to highlight certain features of the image or storyline. A *variation* is an active modification of the original referent to achieve a certain result. The variation may accent certain features and diminish others all the while keeping the identity and coherence of the original form. Finally, *improvisation* allows the agent to modify all structural and functional features of the referent under certain guidelines imposed by the domain. In jazz music, these are the rules of harmony and rhythm. The improviser is careful to make modifications that still retain the outline and identity of the original, even if those boundaries are tenuous. The difference between staying “in” or going “out” in jazz is a measure of how far the improviser strays from the referent. In emergency management situations, the improviser is still aware of key social and technical rules and boundaries that constrain choices as modifications are made to procedures and routines.

In the next section, I discuss the meaning of performance and how the degree of improvisation may change over the course of a performance.

### 3.6 *Performance and the Episodic Nature of Improvisation*

A *performance* happens in a finite period of time, during which a set of agents execute a sequence of actions. In music, this would include the beginning, middle, and end of a concert piece or song. In an emergency management (EM) context, it would be the onset of the crisis, containment, and the transition to a noncrisis or routine state.

Performances are situated in time between an *initialisation* phase and an *epilogue* phase. In the initialisation phase, members agree on a referent and other parameters of performance. The epilogue phase occurs at the completion or near completion of the performance. The epilogue is the final opportunity for new ideas, modification of referent, or closing pattern. In music, this is referred to as a *cadenza*. See Fig. 3.

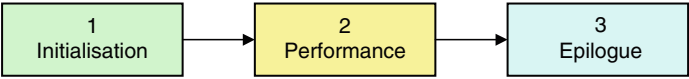


Fig. 3 The performance context

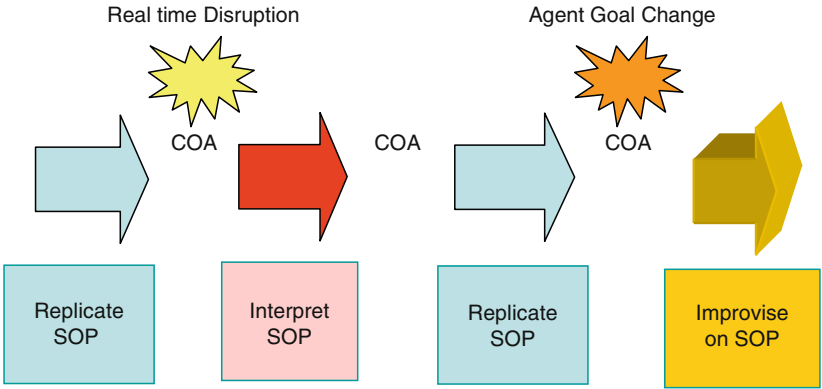


Fig. 4 Episodic nature of improvisation during performance in problem-solving contexts

Within a typical performance, there are usually three subsections. Initially, there is a starting pattern based on the referent. Next is the improvisation section. real-time changes are made to referent as antecedent conditions warrant or as the goals of the agents change. Typically, the performance returns to some restatement of the referent or underlying pattern; the latter provides a sense of coherence.

Each performance is thus a unique *realisation* of the referent. The performance may contain episodes of improvisation alternating with the performance of scripts and routines based on changes in the conditions or the goals of the agents. See Fig. 4.

3.7 *Elements Necessary for Individual and Team Improvisation*

To summarize what has been suggested in the previous sections, we identify the elements necessary for individuals and teams to engage in improvisational behaviors. See Table 6.

3.8 *Improvising Effectively*

In order to improvise effectively, the team must have cultivated several skills, abilities, and conditions (see Table 7).

**Table 6** Necessary elements for individual and team improvisation

Element	Description
Goals	Goals are selected to respond to antecedent conditions
Agents	One or more agents Agents are brought together to achieve goals, e.g., perform a musical piece; contain an emergency situation; perform a surgical operation Each agent must possess knowledge of the task and of the norms that govern team behaviour Each agent accepts risk and uncertainty of task setting
Set of COAs	Agents will choose appropriate courses of action (COAs) from available set to meet goals
Referents	A <i>referent</i> is a cognitive tool that constrains the task and COAs In music, it is the harmony or score. In organisations, routines, SOPs
Opportunity to Perform	Each “performance” is a <i>realisation</i> or variation of the referent that is unique to that situation

**Table 7** Cultivating effective improvisation

Element	Description
Ability to communicate	Improvisation in a team is a conversation Requires excellent listening skills Agents must have a “vocabulary” of “words/phrases” to communicate
Relationships of trust	Agents must trust each other to promote free and open communication
Ability to self-monitor	Requires ability to self-monitor and listen to self, i.e., engage in retrospective and real-time sense making (Weick 1998; Berliner 1994)
Knowledge base	Agents must have complementary bases of knowledge and expertise Agents must share a common base of knowledge related to task environment Requisite variety of knowledge helps handle discontinuities
Working memory	Agents need extensive working and/or external memory to perform
Leadership	Each team has a de facto leader Leadership may be temporarily shared amongst the group members during performance
Client/recipient awareness	Members of the team must be aware of the unique characteristics of the client/recipient and tailor responses and procedures, accordingly.

To begin with, the team should have developed effective communication capabilities. Effective communication is defined as communication that produces the intended effect in the recipient, not just simply sending the message from one point to the next (Tagiuri 1972, 1993). For example, effective communication requires excellent listening skills and the members of the team should have developed a vocabulary of words, phrases, and ideas specific to the domain, to establish meaningful conversations. In jazz music, these are the note sequences that fit specific harmonic structures. In surgery, it would be the vocabulary that identifies the tools, methods, and aspects of human anatomy that intersect during complex tasks.

The second requirement is that the members of the team must trust each other. This is absolutely critical. Trust is a key aspect of team and organisational performance (e.g., Six and Sorge 2008) and especially so in Real-Time decision making contexts. Third, the members of the team must be able to self-monitor. As was stated earlier, “If you are not affected and influenced by your own (notes) when you improvise then you’re missing the whole point” (Weick 1998, using Konitz cited in Berliner 1994, p. 193). Self-reflection in real time is also key. While engaged in conversation with other members of the team, the agent must also listen to himself or herself speak the vocabulary of the domain as the interaction unfolds and make modifications accordingly. Fourth, the team must possess a base of common knowledge specific to the domain as well as other referent domains. This knowledge guides and constrains the choice of “permitted” courses of action selected by the team. Fifth, the team must have at its disposal both in context memory (i.e., memory of the earlier parts of the current performance) and of previous performances.

Sixth, the members of the team may rotate and share leadership throughout the performance. For instance, when jazz groups perform, there is a “passing of the baton” of leadership from one member to the next as each soloist takes his or her turn. The transition from one to the next is swift and effortless. Shared leadership allows each member to perform at his or her highest level of ability, while alternating between “sideman” to featured “soloist.” Together, these factors drive teams to be effective in their improvisations. On the other hand, it should be pointed out that most groups have a *de facto* leader, and although leadership may temporarily shift during performance, the primary leader may assume control at any point during, preceding, and following the performance. This understanding is implicit amongst the members.

Finally, the team must tailor the performance to the unique characteristics (and limitations) of the client or recipient. In jazz music, this is relatively trivial (i.e., the performers must take into account the responses of the audience, who may boo or usher the performers off the stage). In health care, this is of crucial importance and can mean the difference between success and failure. Although all patients are human beings of a certain age and gender, the variance between patients of a given class may be significant, based on different life-styles and environmental factors. The “performers” must, therefore, adapt existing routines to match the unique characteristics of a given individual.

## 4 Implications for Real-Time Dynamic Decision Support Systems (DSS)

DSS continue to represent an important part of IS research and practice (Burstein and Holsapple 2008). The concept of improvisation as “conversation” and other qualifying conditions that have been identified in this work have implications for the design of DSS that support Real-Time decision-making in context. Conventional (i.e., nonReal-Time) DSS typically deliver data and preplanned routines, knowledge,

and scripts to decision makers. Many Real-Time decision systems (RTDS) are designed for semiautonomous control systems that serve to assist or replace human operators (Seguin, Potvin, Gendreau, Crainic, and Marcotte 1997). We suggest an alternative set of design specifications, i.e., we want to help human decision-making teams to respond to situations in real time by engaging in improvisational behaviors and “conversations.” This goal requires different design principles and information systems with different features. In short, we want to support *performances* as opposed to just tasks. We break requirements into pre-performance, performance, and post-performance support components.

### 4.1 Pre-performance Support

Contrary to common thought, improvisers from Second City comics to jazz musicians train extensively to provide them with the facility to create in real time. This paradox of preparation to enable more freedom is not widely understood. However, when a surgical team improvises out of necessity, we instinctively understand the role and importance of prior experience and knowledge. In light of this need, we identify several design requirements. See Table 8.

This pre-performance support component has many aspects of a learning management system (e.g., Yueh and Hsu 2008; Lytras and Pouloudi 2006; Hall and Paradise 2005). We see the system providing support for extensive learning drills and preparation in the procedures of the domain. Easy access to videos and other multimedia illustrations by domain experts will be very useful. Simulations in a variety of contexts would also prepare the user for several scenarios. Fast access to the declarative knowledge of the domain is also necessary for study and preparation, especially for newcomers. Finally, the pre-performance component should have a social networking feature like MySpace or LinkedIn to facilitate communications amongst users. This facility will increase trust and familiarity with current or potential team members. It also will be a means by which novices and peers learn from experts or other peers by cultivating a community of practice (Stein 2005).

**Table 8** Pre-performance support

Support area	Support method
▪ Rehearsal support	▪ Drills and training methods and procedures
▪ Feed-forward	▪ Reviews of experts in similar contexts
▪ Domain learning	▪ Simulations
▪ Referent support	▪ Declarative knowledge libraries
▪ Trust	▪ Build trust of members through social networking

**Table 9** Performance support

Support area	Emphasis	Support method
Referent support	Historical	<ul style="list-style-type: none"><li>▪ Libraries of routines, SOPs, scripts</li><li>▪ Decision tree logic libraries</li></ul>
Case support	Historical	<ul style="list-style-type: none"><li>▪ Histories of previous cases</li></ul>
Knowledge support	Historical	<ul style="list-style-type: none"><li>▪ Knowledge base of task domains</li></ul>
Supporting real-time sense making	Real time	<ul style="list-style-type: none"><li>▪ Real-Time data feeds and representations of current data according to task environment</li></ul>
Conversation analysis and support	Real time	<ul style="list-style-type: none"><li>▪ Natural Language (NL) processing of encoded conversation streams</li><li>▪ Detect and anticipate problem situations, errors</li><li>▪ Verbal cues, emotions</li><li>▪ Allow agents to issue verbal /non-verbal commands to system to execute tasks</li></ul>

## 4.2 Performance Support

The performance component of the support system must support the episodic nature of improvisation during the performance, i.e., it must support varying degrees of improvisation throughout the performance. See Table 9. See Table 9.

In support of relatively routine contexts where replication is the goal, making available libraries of patterns, routines, SOPs, and scripts will be useful. Other useful forms of external history-based support will include case support and a knowledge base of the task domain. Support for the Real-Time aspects of the performance include data feeds and representations of current data indicators, such as a Real-Time executive information system (e.g., Watson, Kelly Rainer Jr., and Koh 1991) or business intelligence system (e.g., Turban, Aronson, Liang, and Sharda 2007). The most important feature of the system will be an ability to analyse conversations of the team members and to make assumptions about changing needs. The system will utilise natural language (NL) processing of encoded conversation streams to detect and anticipate problem situations and errors. Verbal cues, emotions of the team members, and other verbal and nonverbal behavior analysis will be used. This feature is essential to anticipate the need of the team to move from executing routine procedures to higher degrees of improvisation. Because of the multitasking requirements of the team, the system should be able to respond to verbal/non-verbal commands issued by the members to execute commands and tasks.

## 4.3 Post-performance Support

The primary goal of post-performance support is to support retrospective sense making, reflection, after-action reviews, error analysis, and feedback. The consequences of these support features for the organisation and team are individual and organizational learning and memory (Stein 1995; Stein and Zwass 1995) (see Table 10).



**Table 10** Post-performance support

Support area	Post-support type
▪ Retrospective sense making	▪ Rich data and video capture of events
▪ After-action reviews	▪ Data on recipients and outcomes
▪ Error analysis	▪ Templates for knowledge capture
▪ Feedback	▪ Records indexing to enable the review of event data to support after-action reviews, feedback, error analysis
	▪ Social networking support
	▪ Access to libraries of procedures and knowledge for comparison to actual

Many have stressed the importance of reflection (e.g., Garner 1993) and sense making (e.g., Weick 1998) to help people to learn and interpret prior experience. Members of Real-Time task teams need time to process the rich experiences they encounter in RTDDM contexts, in order to learn. Decision support should, therefore, include the use of rich media (e.g., video) to capture events for later review and reflection. Given the intensity of Real-Time situations, it is even likely that participants fail to remember details given a complete immersion in “flow” (Csikszentmihalyi 1991, 2000). Providing Real-Time capture of events is therefore critical. The data can then be used to support sense making, after-action reviews, and error analysis. These activities are indispensable to both individual and organizational learning. The provision of a social networking feature promotes social learning within the team and community of practice (Stein 2005). Finally, feedback on recipients and their outcomes (e.g., patients) is crucial for after-action learning.

**4.4 Systems and Organisational Implications**

While it is outside the scope of this work to articulate a full description of the system features, architectures, and organisational attributes required to support improvisation, we can summarise our general observations. As described above, the system will have the following features and components.

- Database component
  - Access to databases of declarative knowledge pertaining to the subject matter
  - Access to case histories
  - Access to SOPs, scripts, and decision trees
  - Access to rich media libraries that feature video clips and images of events, procedures, and interviews with content experts
- Social networking component
  - Facilitates networking with other professionals in and out of context
- Simulation component
  - Allows for trying out various “what-if” scenarios

- Training component
  - Supports repetitive training in methods and procedures with feedback
- Real-Time data component
  - Provides access to live data feeds on Real-Time events and news
  - Real-Time event capture
- Natural language-processing component
  - Real-Time analysis of actor conversations
  - Real-Time action-taking in response to verbal cues
- Learning and knowledge-management component
  - Provides a “scratch-pad” for agents to perform after-action reviews and make explicit learning from each event

Together, these components will provide a supportive environment for improvisational behaviours amongst the agents in context. Organisations that support the development of these systems will benefit from certain characteristics. Improvisation will likely flourish in the context of learning organisations (Argyris and Schon 1978). Learning organisations encourage knowledge testing and refinement. Agents in a learning organisation are relatively free of defensive routines and are simply motivated to serve clients more effectively over time. Clearly, more research is needed to flesh out the full range of organisational attributes that support improvisational behaviours.

## 5 Summary and Conclusions

Improvisation and RTDDM are inter-related concepts and contexts. Although emergency response teams and jazz groups do not seem to have much in common, they are, indeed, examples of teams operating in dynamic Real-Time choice environments. Dynamic Real-Time decision-making contexts are fluid, and the nature of problem solving around which decision support is built is both changeable and episodic.

What distinguishes one context from others is the structure of the problem space and most importantly, the MoC of the decision space. MoC is a construct defined by Jones (1991) to describe the impact of decision outcomes on external stakeholders in the realm of ethics. For instance, MoC clearly differentiates jazz contexts from emergency response contexts in terms of risk.

What they share, however, is the delivery of a *performance*. During performance, the degree of improvisation varies. We have shown that the degree of improvisation falls along a continuum, with at least five categories identified: replication – interpretation – embellishment – variation – improvisation. Periods of replication are punctuated with periods of improvisation based on changing conditions and revised goals of the team members. Agents are constantly slipping into and out of

various contexts; so, it is not sufficient to simply characterise a team's performance as "by the book" or improvised; it is likely to contain elements of both.

The nature of improvisation has implications for the design of DSS. These requirements have been broken into pre-performance, performance, and post-performance specifications. The goal of pre-performance support is to provide access to declarative and procedural knowledge about the domain and to enable team members to sharpen their knowledge about the domain and train in skills required for the domain. Social learning is encouraged through features found in social networking sites. The goal during the performance phase is to support Real-Time information representation and to anticipate changes in the problem/decision context in both problem structure and MoC. Additional research is needed to explore the episodic nature of performance (i.e., RTDDM) as contexts change. Finally, the goal of the post-performance phase is to support retrospective sense making, learning, and the development of organisational memory (Stein 1995; Stein and Zwass 1995). Future research needs to be conducted to implement these ideas with the use of appropriate systems technologies.

Another area of future research is to explore the development of semi-autonomous agents that would (a) help recognise improvisational contexts and (b) intervene in improvisational contexts to increase the variety of choices and to help generate context-appropriate outcomes for team members.

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