Theoretical Principles for Representing Business Process Models: The Marriage between Semiotics & Cognitive Psychology

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Abstract

Business Process Models advocate the use of symbolic notations to represent business processes. Influenced by system engineering and mathematics, the application of these notations involves technical processes designed by engineers, undertaken by technically trained analysts for the use of largely technical people. However, the majority of business process stakeholders are non-technically inclined with a business or administrative background. While some notations are comprehensive, they can be visually and technically complex; and cognitively difficult to understand. Others are arbitrary geometrical symbols where their intended semantics are difficult to comprehend. While such representational constraints prevent effective communication of process knowledge, there is a lack of research evidence on theoretical principles for choosing and using these existing sets of notations. This paper proposes essential theoretical principles in advocating set of notations for representing business process model. Through literature reviews and comparative studies, this investigation critically appraised existing sets of notations. It advocates the use of semiotics and cognitive psychology as the theoretical foundation for this proposal. A qualitative comparative analysis will be applied to evaluate the viability of this proposal. While the contention is to reduce the identified representational problems, the essence is to improve appreciation of organizational processes.

Keywords: Business Process Modelling, Semiotics, Cognitive Psychology, Process Improvement, Effective Process Knowledge

1. Introduction

The importance of business processes to organization (Phalp 1998; Warboys et al. 1999), purposes for modelling them (Huckvale & Ould 1995; Kueng & Kawalek 2000) and their generic constructs (Ould 1995; Katzenstein & Lerch 2000; Kueng & Kawalek 2000) have been widely discussed. In essence, with the use of symbolic diagrams, business process modelling (BPM) communicates the knowledge on the complex reality that existed within a business environment. These appraisals are deemed important for any business process improvement initiatives (Huckvale & Ould 1995). As reported in Melao and Pidd (2000), there are 25 different methodologies, 72 different techniques and 102 different tools in support of BPM. These approaches adopt numerous different sets of notations to model their business process perspectives. Through critical literature reviews and comparative studies, unfortunately, this research failed to gather clear evidence on scientific justification for advocating specific types of notational symbols. This research
revealed some common inadequacies among these above approaches that complicate effective communication between various stakeholders. Generally, these approaches address the needs and understanding of system engineers and technical analysts rather than the majority of business people, who are largely non-technical business process stakeholders.

Such unclear empirical evidence to justify advocated principles in representation which is very much “technocentric” could reflect upon cognitive psychology and social issues to overcome these identified constraints (Katzenstein & Lerch 2000). In addition, since BPM uses symbolic notations to represent process abstraction, semiotics the science of signs (such as notational symbols) as advocated by Pierce (1839-1914) could provide insights in optimising the meaning inferred by such symbols. The aim of this research is to propose a theoretical principle that governs the choice and use of symbolic notations for BPM. Its objectives are to appraise the principles of cognitive psychology and semiotics, integrate them as a combined principle governing BPM symbolic representation, evaluating this principle against existing sets of notations and identify future work in balancing the social as well as technical considerations necessary in BPM for the purpose of process improvement initiative.

1.1. Representational Inefficiency of Existing Notations

A key question that this research wishes to identify is why existing BPM techniques advocate the use of a specific set of notations to represent business process. This section also highlights deficiencies in the use of symbolic notations to infer clear representational semantics, particularly leading to effective communication of process intentions as intuitively as possible.

Despite numerous literature reviews and investigative comparisons on various existing BPM techniques conducted by this research, there seems to be an absence on the reason why majority of the current BPM techniques chose their existing sets of notations. In support, Katzenstein and Lerch (2000) claim of a lack of empirical evidence emphasizing on the importance of representations in modelling processes. Hahn and Kim (1999) also observed that existing models lack any theoretical framework, particularly for the cognitive processes involved in manipulating these symbolic diagrams. Users are left to choose diagrams without knowing which diagrammatic representation is more appropriate. Similarly, model designers have to devise cognitively compelling diagrams without any guidelines or theoretical principles to assist them (Hahn & Kim 1999). However, Warboys et al. (1999) claimed that debating which notation is best for modelling “in some absolute sense is fruitless” because “the exigencies of a given initiatives dictate the notation that are likely to be the most helpful”. In contrast, if one is to decipher some of the existing sets of notations (see legends in Figure 1), all of them are intuitively meaningless. While some are commonly used symbols, others are merely geometric shapes to the uninitiated. Apart from the arrows, which may infer pointing in a specific direction, the different types of directional arrows will only confuse any initial understanding that one may have been established. These symbolic notations are arbitrarily assigned with meanings. Advocating intuitively meaningless and in some instances uncommon symbols to represent process elements, will only add to the
complexity in communication and understanding of the intended representations. According to Moore (1993), “the biggest problem we have with communication is the fact that people use language to mean different things”. This is true about the directional arrow if a set of notations is a form of communication language.

In analysing representational inefficiency within existing BPM techniques, Huckvale and Ould (1995) cited that Data Flow Diagram (DFD) suffered from limited notational representation vocabulary with imprecise details on activity sequence and concurrency. DFD notations focus on data objects and do not represent roles (people responsible for performing set of activities within a process), nor the interactions between these various roles. In addition, DFD notations express neither the dynamic behaviour nor the time dimension within a process (Barnard 1999).

In the case of Integrated DEFinition Suites (IDEF) by USAF (1981) and recently by KBSI (2001), while IDEF0 notations represent elements on behavioural and organizational perspectives, it adopts very much a data-oriented view (Huckvale & Ould 1995). IDEF0 “captures only a small variety of process features” (Earl 1994). It addresses process constraints and mechanisms, but it does not show social relationships among the latter (Huckvale & Ould 1995). Furthermore, IDEF0 strict hierarchical view of human activity is not realistic and may inhibit mapping of existing processes. IDEF0 is comprehensive but visually complex particularly on its level of decomposition, which are cognitively difficult to navigate (Katzenstein & Lerch 2000).

In addition, the Process Map by Rummler and Brache (1990), an extension of the traditional flowchart, restricts representation on process interaction to a unidirectional flow, which fudged other types of interactions that are common within a typical business processes (Huckvale & Ould 1995). Similarly, Action Workflow by Winograd & Flores (1987) is impractical to map processes as commitments between two parties, since not all processes can be represented in such a fashion (Huckvale & Ould 1995).

Katzenstein and Lerch (2000) claim that the Role Activity Diagram’s (RAD) set of notations are mere symbolism with no specific semantic intent. While its notations suffer from being highly abstract and hard to remember, its basic triangle shape is used to represent 2 different semantics in 2 different ways. RAD concurrent activity, represented by an upright triangle ($\bigtriangleup$), is reminiscent of the logical ‘and’ symbol and its business condition, represented by an upturned triangle ($\nabla$), is reminiscent of the logical ‘or’ symbol (Huckvale & Ould 1995). This will be confusing to some. Simultaneously, RAD only labels the interesting activity states that require attention (Huckvale & Ould 1995). While it reduces complexity in considering only those elements that are necessary, it exposes itself to the possibilities of overlooking a probable state that might be equally important. In addition, RAD business rules restrict its notational representation only towards diagrammatically representing the pattern of activity sequencing, decision-making and concurrent activity. It does not highlight the event that triggers such business conditions or the social behaviour that binds its roles to respond in certain socially acceptable ways. Neither does represent more than one business rule, which may be embedded within a single activity.
1.2. What Makes an Effective BPM Representation
Katzenstein and Lerch (2000) extrapolation from the cognitive psychology in addressing limitations in modelling representation provided clear reasons for the need to justify the choice of symbolic notations for effective BPM representation. Others have raised similar concerns for the need to elicit accurate semantics from such representations (Phalp 1998; Robinson & Bannon 1991; Larkin & Simon 1987). Drawing attention to Semiotics (Morris 1938; Stamper 1973; Solomonick 2002), this investigation believes that such semantic constraints could be addressed.

Poor representation can affect ease of understanding a business process, particularly problems within the process (Katzenstein & Lerch 2000; Kaplan & Simon 1990). Larkin and Simon (1987) identified that using graphical representation could significantly assist in problem solving. This is especially true when information is grouped together to enhance useful cognitive operations that influence better inference making. Solomonick (2002) raised similar findings in addressing the issue of complexity in signs representations.

Furthermore, Phalp (1998) reported that even a simple representation is sometimes too complex for certain users. He claimed that users are not prepared to invest the time to understand complex or formal modelling approaches, which require technical experts to validate and appreciate them. The main problem is that the majority of process stakeholders are non-technically inclined. This led to the need for sacrificing rigor in order to facilitate discussion and understandability. Phalp (1998) also highlighted that the type of audience must be identified so that an appropriate graphical diagrammatic notations with clear semantics are readily understandable. Such representation uses minimum number of intuitive and readily recognizable symbols that must be easy to understand for the uninitiated. This observation is in direct contrast to the constraints identified in section 1.1.

However, Curtis et al. (1992) claimed that it is difficult to establish a representational format, which is universally understood. He suggested that representation model must be flexible, expressive and comprehensive. Robinson and Bannon (1991) acknowledged this dilemma, while addressing problems faced by semantic communities (different groups of people who do not share similar jargons, norms and perspectives of the real world). Such communities adhere to individual ontologies, epistemologies and conventions. Robinson and Bannon also identified the problem of ontological drift (lost of actual meaning when information is interpreted and further disseminated to others) while communicating with different semantic communities.

2. Research Methodology
The main problem this research needed to address was the absence of a theoretical principle that governs the choice and use of symbolic notations for BPM representation. This research aimed at proposing an essential theoretical principle to overcome this inadequacy. The research objectives are to appraise the principles of cognitive psychology and semiotics, integrate them as a combined principle governing BPM
symbolic representation and evaluating this proposed principle against existing sets of notations before briefly discussing its future work. Critical literature reviews and analytical comparative studies formed the main thrust in this research investigation. Two existing BPM approaches, IDEF and RAD; and a newly developed Norm Process Chart (NPC) set of notations (Jaffar, 2003) will be used to evaluate the proposed theoretical principle.

3. The Theoretical Foundation
The essence from the above analysis revolves on the issue of communication to affect rigorous understanding in addressing a given BPM representation. The main concerns are with the content of the model, the type of notations to be used and their presentation formats that can ensure effective appreciation facilitating appropriate discussion by all business process stakeholders. Katzenstein and Lerch (2000) claim these problems could be overcome by addressing cognitive psychological and social issues. In addition, BPM sets of notations are symbolic signs used to represent certain arbitrary meaning. Such purpose implicates Semiotics (the science of signs) as advocated by Charles Pierce (1839-1914) and later by Charles Morris (1901-1979) with semiosis a process which uses sign to produce meaning inferred by sign (Morris 1946).
3.1. Cognitive Psychology Influencing Effective Communication

Process modelling is about abstracting the complexity of the real world and communicating it among its stakeholders through some form of representation, i.e. symbols in diagrams. Due to the limitation in human sensory systems, one will be selective in one’s perception (Mullins & Hicks 1996). Perception is the mental function of generating significance to individual stimuli (Mullins & Hicks 1996). Past experiences affect the stimuli perceived instantaneously and influence how the stimuli are understood, processed and responses to a given interpretation. Inflicting a larger number of such stimuli will intensely influence individual perception (Mullins & Hicks 1996). By organising stimuli into meaningful grouping based on their proximity to a concept representation will also influence individual perception. Communication and perception are inextricably bound (Mullins & Hicks 1996). Hence, improving perception will influence effective communication.

The challenge of a limited human sensory system is to minimize the amount and effort of information search that will be required in interpreting, understanding and solving problems (Hahn & Kim 1999). According to Larkin and Simon (1987), different diagrammatic representations projecting similar information contents, vary in their computational efficiency (refers to ease and rapidity of inference making by an individual) for providing perceptual cues. These cues facilitate effective reasoning and manipulating of information to ensure effective understanding and communications of the intended representations.

Kulpa (1994) advocates diagrammatic representation to represent data and information; and diagrammatic reasoning which use inspection and direct manipulation of a diagram as the primary means of inference making since a well-represented diagram is one that supports the cognitive processes effectively, where one could easily perceive and reason with its projected meaning (Hahn & Kim 1999). These processes are constrained by the grammatical rules of decomposition and layout of the represented knowledge. Such decomposition divides knowledge into meaningful units represented by a separate graphical primitive, which could be aggregated together or represented individually. The rules on representation layout determine how to provide meaningful information by optimizing the presentation space within the diagram. The intention is to facilitate clear and concise representations. Hahn and Kim (1999) also observed that different symbolic notations in diagrams inflict different cognitive operations, which are more difficult in some as compared to others.

3.2. Organisational Semiotics: Properties of Notational Symbols

Charles Peirce’s definition of sign is “something which stands to somebody for something in some respect or capacity” (Chandler 1998). Humans associate intrinsic meaning to signs based on their past experience in direct relation to natural phenomenon (Chandler 1998). As humans evolved, they invented arbitrary signs to represent complex meaning (Solomonick 2002). In-depth discussions on Peirce’s theory of sign and various sign classifications have been well documented (Stamper 1973; Chandler 1998; Marcostica 2001 and Jaffar 2003). This section introduces organizational semiotics framework (Stamper 1973), an extension of Peirce’s theory within the domain of information system.

Since BPM representations involve both technical as well as non-technical stakeholders, there is a need to introduce theoretical principles that emphasis the socio-technical aspects of using notational symbols for representing business process (Stamper 1973).
This investigation adapted the organizational semiotics framework by Stamper (1973), to define the properties of notational symbols in representing business processes. It emphasised the principle of semiosis (Morris 1946) in determining the projected meaning by a notational symbol in representing a business process concept. Collectively, physic and empiric are influenced by syntactic in order to project the pragmatic from the implied semantic, which in turn inflicts how an interpreter responds to their sign interpretation (social). When aggregated together, an interpreter processes each division simultaneously during interpretation. Table 1 briefly discusses the proposed properties of notational symbol for representing business processes. Further elaboration can be found in Jaffar (2003).

### Table 1. Properties of Notational Symbols

<table>
<thead>
<tr>
<th>Technical Aspects</th>
<th>Social Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physic</td>
<td>Semantic</td>
</tr>
<tr>
<td>Analyses the physical shape of the sign to be used. Base on arbitrarily geometrical symbols or natural iconic signs which are more intuitive in their meanings (Jaffar 2003)</td>
<td>Defines the rules for eliciting the exact meaning from each sign used and their conformance to users’ familiarity and acceptability</td>
</tr>
<tr>
<td>Empiric</td>
<td>Pragmatic</td>
</tr>
<tr>
<td>Analyses the degree of abstractness in a sign. A geometrical sign is highly abstract as compared to intuitive iconic sign. It analyses the level of complexity in the various types of signs used</td>
<td>Analyses the intention projected by a sign</td>
</tr>
<tr>
<td>Syntactic</td>
<td>Social</td>
</tr>
<tr>
<td>Defines the rules for using the various signs. These include the categories of information to be addressed, the organisational layout of such signs on the diagram, relationship between signs and the target audience</td>
<td>Addresses the social obligation in terms of acceptable norms that should be perceived from the interpretation of such signs</td>
</tr>
</tbody>
</table>

### 4. The Proposed Principles for BPM Representations

Critical appraisal on all of the above suggested various areas that require considerations when modeling business processes. In eliminating representational problems in modeling essential business process concepts (Jaffar 2003), the theoretical principles underlying the choice and use of notations must be considered. The types of notations to be used should not be any geometrical symbols arbitrarily assigned with meanings. Choice of symbols must minimize cognitive constraints, which are intuitively meaningful in their representations and when used in BPM, retained its original meaning and intended representation. In addition, with the intention to communicate process knowledge to various stakeholders, aspects of cognitive psychology influencing effective communications must also be emphasized. This can only facilitate better dissemination, interactions, and accuracy in understanding process knowledge. As a result, this investigation proposes an amalgamated new set of theoretical principles for BPM, based on existing theories described in section 3. The proposed principles are grouped into the following categories (see Table 2):

### Table 2. Properties of Notational Symbols

<table>
<thead>
<tr>
<th>Theory</th>
<th>Requirements</th>
<th>Categorised Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Sensory System</td>
<td>• Influencing individual stimuli with minimal symbols&lt;br&gt;Organising stimuli into meaningful grouping</td>
<td>Effective Communication &amp; Suitable Notations</td>
</tr>
<tr>
<td>Minimising Information Search</td>
<td>• Facilitating computational efficiency&lt;br&gt;Effective knowledge understanding and reasoning</td>
<td>Effective Communication</td>
</tr>
<tr>
<td>Diagrammatic Representation</td>
<td>• Ease diagrammatic reasoning to facilitate ease of perception and reasoning&lt;br&gt;Simple diagrammatic decomposition&lt;br&gt;Layout optimisation by positioning notations effectively</td>
<td>Presentation Layout &amp; Suitable Notations</td>
</tr>
<tr>
<td>Physic</td>
<td>• Notational symbols must be intuitively simple</td>
<td>Suitable Notations</td>
</tr>
<tr>
<td>Empiric</td>
<td>• Minimise level of abstractness, least abstract the better</td>
<td></td>
</tr>
<tr>
<td>Syntactic</td>
<td>• Group related information together&lt;br&gt;Optimise layout to inflict better representational meaning&lt;br&gt;Simplify expression of symbolic meaning</td>
<td>Suitable Notations &amp; Presentation Layout</td>
</tr>
<tr>
<td>Semantic</td>
<td>• Highlighting primary sign that interpreters need to know</td>
<td></td>
</tr>
</tbody>
</table>
4.1. Suitable Notations

**The principle:** Emphasised that different types of symbolic notation must be minimal, graphically recognizable and visually less abstract to all stakeholders. In addition, each notation must be intuitively meaningful in its individual as well as collective representation and easy for stakeholders to grasp the concepts that these notations are intended to prescribe.

Based on the adapted organizational semiotics framework, the choice of notations will address the socio-technical needs of all process stakeholders. The purpose is to minimize the learning curve and reduce the difficulties of appreciating new knowledge in representing process elements. Simultaneously, these notations must reduce the possible memory constraints in absorbing and storing the arbitrarily assigned meaning for such notations. *Similar basic symbols with different contextual meanings must be avoided.* The minimal number of symbols will facilitate the limited sensory systems to focus more effectively on deducing a given process knowledge. The contention is to simplify stakeholders’ cognitive perceptions by facilitating qualitative reasoning, instead of straining them. Upon seeing a notation, interpreter is familiar with its meaning to deduce its projected intention and obliged with acceptable norm/s.

4.2. Presentation Layout

**The principle:** Emphasised the effective positioning and grouping of notations facilitate clear and concise representation. It should highlight logical flow of process activities within and between different organizational sub-units (departments or sections within functional areas) and the various agents/roles performing these process activities.

The contention is to provide meaningful information by optimizing the presentation space or layout within the model. The aim is to avoid cluttering of massive amounts of information together. Such decomposition will segregate specific information to be observed from different perspectives as well as “drill-down” to different level of abstractions, addressing activity multiple states or business rules that constrain its execution. Focusing on logical flows also highlight the interactions between the various activities and the associated roles. This ‘process roadmap’ can only increase interactions and productive negotiation between these roles. The purpose is to achieve cognitive knowledge on what a process does, the intuitive and tacit knowledge on how the process works or possibly does not work and also why a process operates as it does (Katzenstein & Lerch 2000). The latter reveals the causal relationship between process entities, which will inflict greater understanding of the process complexity. As such, these considerations expand the model’s content to include issues concerning the logistic aspects such as time and cost, the psychological aspects such as motivations and frustrations as well as sociological aspects in terms of relationships and conflicts (Katzenstein & Lerch 2000). On the contrary, the logical sequences, constrained by conditional rules, can be used to highlight the execution timing for each activity within a process.

4.3. Effective Communication

**The principle:** Emphasised factoring stakeholders’ limited sensory systems through optimizing simple and very familiar graphical symbols for representing process elements.
Simultaneously, is to contrast these stimuli against pleasant background and placing them into meaningful groups.

The intention is to direct their specific attention to pleasant stimuli by increasing computation efficiency in interpreting process model through minimizing ontological drift across different semantic communities. Advocating such common symbols without changing their original intended semantics and usage would optimize stakeholders’ previous experiences. Such stimulus will affect stakeholders’ perceptions instantaneously. They will influence how these perceptions can be processed, understood and interpreted accurately by a given representation. The aim in contrasting different stimuli is to minimize the amount and effect of information searching within stakeholders’ memory. Optimizing such cognitive responses will only improve reasoning and manipulating of information by the individual stakeholder.

5. Evaluating The Proposed Theoretical Principles

NPC, RAD and IDEF sets of notations (see Figure 1) were used to model an Inter-Library Loan business process. Findings from such comparative analysis of these models provided the qualitative evidence in evaluating the proposed theoretical principles.
5.1. Evaluating the Principle of Suitable Notations
The main issue is to emphasize intuitively meaningful symbols which are least abstract yet graphically recognisable in representing processes. Numerical calculation in Table 3 is based on No. of Signs * Weight value for each classification. In addressing the physic and empiric properties of Symbols based on semiotics classification of signs (Jaffar, 2003), with reference to the legends, Table 3 showed that not only does NPC uses the least number of individual symbols but these symbols are also less abstract as compared to others. The arrows depicted least abstract metaphorically iconic symbol of indicating a direction as compared to the arbitrarily assigned symbolic notations such as natural language and the geometrical shapes of notations. Unlike others, RAD uses a line depicting process thread to highlight flow and sequence of activities. NPC and IDEF use arrows to determine logical flow of process activities. NPC uses merely natural language active verb phrases to project activity physical action. Others incorporate natural language within geometrical symbols of square or different types of rectangles to imply activity constrained by other specific process technical constraints. NPC geometric notations are visually simple and commonly used as compared to RAD and IDEF.

Table 3. Comparison Matrix Based on Semiotics Classification of Signs (Jaffar, 2003)

<table>
<thead>
<tr>
<th>Classification Of Signs</th>
<th>Types of Notations</th>
<th>NPC (N)</th>
<th>RAD (R)</th>
<th>IDEF (I)</th>
<th>Total No. Of Signs</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metaphor (Weight = 3.6)</td>
<td>Note: RAD activity label is attached to its greyed square box</td>
<td>2 3 4 5 6 7 8 9 10</td>
<td>2 3 4 5 6 7 8 9 10</td>
<td>2 3 4 5 6 7 8 9 10</td>
<td>N R I N R I N R I</td>
<td></td>
</tr>
<tr>
<td>Natural Language (Weight = 4.0)</td>
<td>Activity Label</td>
<td>1 6 8 46</td>
<td>1 6 8 46</td>
<td>1 6 8 46</td>
<td>N R I N R I N R I</td>
<td></td>
</tr>
<tr>
<td>Notations (Weight = 4.3)</td>
<td>Sub-Organisation Label</td>
<td>3 8 9 16 50 57 5 28 13 32 183 62</td>
<td>3 8 9 16 50 57 5 28 13 32 183 62</td>
<td>3 8 9 16 50 57 5 28 13 32 183 62</td>
<td>N R I N R I N R I</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Least No. Of Signs</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>N R I N R I N R I</td>
<td></td>
</tr>
<tr>
<td>Least Abstract</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>N R I N R I N R I</td>
<td></td>
</tr>
</tbody>
</table>

In comparing Figure 2, the syntactic property renders RAD as confusing in deducing process logical flow to the uninitiated. When applying the norm of reading from top to bottom and left to right, leads to complication at activity flow prior to “Enter
Corresponding Details” as well as “Submit Request to External Library” (Figure 2a). In contrast, NPC (Figure 2b) with its directional arrows forces a reader the obligation of doing both entering and confirming details prior to submitting a request. While IDEF also uses arrows, evaluations on its physic and empiric properties are more complex than NPC. In Figure 2, NPC maintains a better readability with explicit graphical visualization that minimizes ambiguity and abstraction in concept representations as compared to RAD.

Semantically, arrows in NPC and IDEF are indicative of its intention and expected obligation on an interpreter’s part. However, its absence in RAD complicates representation without intuitively indicating which activity preceded the other. The arrows (bold and broken lines) in IDEF and triangular shapes (upright and upturn) in RAD, uses similar basic symbol but with different contextual meanings. While RAD upright triangle infers activities performed in parallel and the upturn triangle connotes branching due to a decision, their semantic representations arbitrarily inferred specific intent, which is far from acceptably common. Similarly, IDEF geometric symbols are neither intuitive nor comprehensive enough to infer a direct connotation to anything common in reality. NPC physical shapes are visually less complicated and graphically recognizable than others. While two of its notations fair no better than RAD and IDEF, its ampersand symbol adopts similar convention that suggest association or relation of one to another. It implies the grammatical conjunction “and” in most of the natural languages. In contrast, IDEF usage of ampersand is more complex with the inclusion of various vertical lines within a square. In other instances, the letter “X” or “O” replaces the ampersand symbol implying an exclusive and alternative process branching, respectively. NPC is designed to reduce transformation rule (Stamper 1996) by retaining the meaning of symbols as they are commonly used. Hence, increase immediate comprehension of meaning leading to better and accurate interpretation of a representation.

![Figure 3 - Comparing Conceptual Representation for Pragmatic Consideration](image-url)

In terms of collective representation (see Figure 3), NPC adhered to the pragmatic property more intuitively than others. “Gather Corresponding Details” and “Confirm borrower’s details” cannot get simpler and clearer in its projection of its intended meaning. While in RAD such intention is cluttered with unnecessary symbols that do not add-value to its interpreter, IDEF cluttered all its representations with format layout and identifier to uniquely segregate one from the other. NPC optimizes the use of existing common knowledge and shared assumption from the English language. In addition, NPC uses of conditional arrow with its variable value (see Figure 2b) provided additional information on the cause for process branching. Such application of pragmatic principle is absence in IDEF and vaguely addressed in RAD (see Figure 2a).
Within the *social* principle, RAD thread line does not implicate the same level of social obligation as in the use of metaphoric directional arrows. IDEF and NPC use of arrows enforce a definitive move towards a specific path that an interpreter is obliged to follow. RAD thread line implicates neither its starting nor ending point explicitly. Likewise with NPC conditional arrow as compared to RAD upturn triangle in conveying divergence of process flows. Similar effect can be expected of NPC ampersand symbol as discussed above.
5.2. Evaluating the Principle of Presentation Layout

In terms of the model structural layout, NPC and RAD group representations of activities performed by a role within the agent’s boundary. These representations are integrated together within a single diagram. IDEF suites divide its models into 10 different separate diagrams for multiple purposes. Though IDEF may avoid information cluttering, NPC and RAD provided a single perspective without any loss of information. With reference to Figure 1c, IDEF presentation is visually more abstract, less appealing and not influencing cognitive stimuli. In addition, while RAD and NPC model incorporate roles performing processes, IDEF merely highlights the roles involved at a higher level of abstraction (in IDEF0) without describing which role explicitly performs the activities involved (in IDEF3). Unlike RAD and IDEF, NPC elevates the level of information further by grouping the modelled roles within their sub-organizations (departments). This facilitates an immediate focus onto a specific sub-unit or even a role within that sub-unit. NPC optimizes cognitive knowledge by expanding the model’s content to include not only the logical aspect of a business process, but also its psychological as well as sociological aspects.

While NPC maintains its directional arrow as activity sequence as well as interaction between activities, roles and sub-units (See Figure 1a), which are absent in RAD and IDEF. In the case of RAD, its representation for Interaction uses two additional notational symbols of an interaction initiator and an interaction receiver (see Figure 1b). Additional symbols leads increase in the modelling complexity by introducing negative stimuli and congesting the limited sensory system with unnecessary representation. Similarly, IDEF introduces different additional symbols to provide in-depth process knowledge. Details such Exclusive OR (“X”) segregated from its OR condition (“O”), identifier to all of its activities, activity synchronous and asynchronous may be necessary in modelling manufacturing process flows but information is overwhelming when modelling business processes.

5.3. Evaluating the Principle of Effective Communication

Collectively, effective communication is directly influenced by the previous two principles. While suitable notations acted as the vocabularies of BPM representational language, presentational layout emphasises the language grammatical constructs. Analysis of the above two categories, it clearly substantiated NPC capabilities in facilitating effective communication in BPM representations. With its minimal number of readily recognizable individual symbols that retained their originally common assigned meanings, NPC set of notations accommodate the human limited sensory system. Optimizing familiar symbols from past experiences, NPC inflicts pleasant stimuli by organizing its representation into a meaningful grouping backed by pleasant contrasting shades is its background. Such features ease interpreters’ ability to cognitively focus their attention to intensely influence their perception of the representation effectively. The larger number of notations with uncommon arbitrarily assigned meaning and complicated syntactical rules by RAD and IDEF, lead to an overflow of the interpreter’s limit sensory system. This will have adverse negative effect to the cognitive perceptual stimuli and hence, effectiveness in communication.
NPC presentation layout minimizes information search by addressing not only the process’s logical aspects but also psychological and sociological as well. These are catalysts to process knowledge computational efficiency by avoiding possible ontological drift due to misinterpretation among the different semantics communities (see Figure 3). Hence, NPC improve interpreter’s cognitive responses facilitating their perceptions, reasoning and manipulating of information leading to rapid inference making and accurate interpretation and appreciation of the model.

5.4.Evaluating Research Findings and Limitations
The above successfully provided the quantitative as well as qualitative evidences in applying the essential theoretical principles to segregate differences and identify strengths and weaknesses of the three sets of notations in modelling business processes. These findings significantly correlated to another empirical study that revealed objective evidences for preference of the newly developed NPC sets of notations (Jaffar et al. 2003). Among numerous variables analysed, self-explanatory symbolic meaning, easy to understand diagram and activity flow and sufficient information to describe processes, the analysis showed an overwhelming preference towards NPC. Even the analysis on a negative variable (which symbols are confusing), NPC achieved an overall means of about 50% less confusing than other sets of notations.

While the proposed principles have been incorporated within the newly developed Norm Process Chart (NPC) set of notations, further comprehensive investigation and thorough analysis of its findings can only improve the viability and effectiveness of the proposed principles. Evaluating these principles against widely acceptable standards in the like of UML business process models will highlight any possible constraints within these principles. Similarly, further analysis against several other modelling techniques in representing various organisational problems and domains can only reveal its stability and thoroughness of these principles.

6. Conclusion
A socio-technical set of notations for representing business process model have been presented to overcome the technically inclined existing sets of notations. The absence of theoretical principles, governing the choice and usage of notations for BPM, has been replaced with the introduction of semiotics cum cognitive psychology principles. The proposed theoretical principles were comparatively evaluated against 3 sets of notations to prove its viability qualitatively as well as quantitatively. The introduction of NPC set of notations (which were developed based on the proposed set of principles) and its significant preferences against RAD and IDEF provided further evidences of the effectiveness of the proposed principles. The above results, backed by findings from other conclusive research, showed that representational constraints preventing effective communication of process knowledge can be significantly reduced (if not eradicated). Simultaneously, inclusion of such a theoretical foundation will only increased the scientific value of a particular BPM technique.

Further investigation is necessary to validate the proposed theoretical principles. While UML diagrams such as Activity (and perhaps, to a lesser extent Use-Cases and State-
chart) projects business processes, another initiative by Business Process Management Initiative (BPMI.org) has introduced a BPM set of notations, hailed to be the industrial standard that complies with US based Federal Information Processing Standards (FIPS). Comparing such industrial standards can only improve the robustness of this proposed theoretical principle.
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