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# DFDs:Evolutionary Status andA Cognitive Based Empirical Investigation of Level 0 DFD Clarity

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# DFDs:
# Evolutionary Status and
# A Cognitive Based Empirical Investigation of Level 0 DFD Clarity...

## Implications for Level 0 DFDs and Diagramming in General

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**ABSTRACT/SUMMARY**

The data flow diagram (DFD) has been a development, communication, and documentation technique in the systems analyst toolbox for almost two decades. Both surveys and expert opinion confirm that the data flow diagram is a popular and most preferred tool of its class structured analysis and design tools (Whitten,Bentley, & Ho, 1986, p.221). Recent surveys indicate as much as an 80% usage of DFDs (Jain & Purao, 1991; Martin, M., 1991, p.98). These surveys also indicate that of all the "structured tools", the DFD is consistently used more than the others. Numerous authors attest to the DFD's popularity (Vessey & Conger, 1994; Vessey, Jarvenpaa, & Tractinsky, 1992; France, 1992; Kung 1991; Abrahami 1993, Liu, 1993; Warren, Stott, & Norcio, 1991; Protsko, Sorenson, Tremblay, & Schaefer, 1991; Capron, 1986; Gore & Stubbe, 1988; Kendall & Kendall, 1988; Martin & McClure, 1985; Martin, M., 1991; Powers, Cheney, & Crow, 1990; Wetherbe, 1988; Whitten, Bentley, & Ho, 1986; Yourdon, 1989, etc).

The DFD continues to evolve and to be found useful as an adjunct to new developments in systems analysis and design techniques. Some researchers have concentrated on improvements designed to overcome the congenital DFD weakness in depicting timing and control (Richeter & Maffeo, 1993; Liu, 1993; canfora, Cimitile, & De Carlini, 1990; Robson & Henderson, 1993; France, 1992). These and other improvements have been implemented in CASE tools (Chen & Chung, 1992; Tao & Kung, 1991; Protsko, Sorenson, Tremblay, & Schafer, 1991; Warren, Stott, & Norcio, 1992). The DFD is also being integrated with techniques and methodologies that are often considered mutually exclusive. For example, Kuo (1994) presents an object-oriented methodology for deriving entity-relationship diagrams from DFDs.

Accordingly, the DFD is one of few tools consistently included in texts covering computer systems development. Other tools such as: action diagrams, Nassi-Shneiderman

charts, Warnier-Orr diagrams, state transition diagrams, etc. are not always covered. Instead they are either omitted or another similar function tool is presented. For example, pseudocode and/or structured english are often presented as tools to be used to complete process definitions instead of action diagrams.

Paradoxically, authors such as Martin and McClure (1985,p.162) emphatically note that although DFD use is widespread, the literature concerning DFD construction and use remain problematic that DFD clarity, especially in texts, is decidedly inadequate. Here, the level 0 DFD is examined to determine the sources and causes of its clarity difficulties. A Cognitive Information Processing-- Information Theory based perspective (CIPIT) is developed to (1) explicate precisely what the clarity problems are and (2) to provide an empirical, practical, scientific basis from which to form a minimum set of rules for highclarity level 0 DFD construction.

The CIPIT based rules extracted/developed here are applied specifically to the level 0 DFD but are largely applicable to diagramming in general because they address fundamental human information processing realities. The CIPIT rules guide the construction of a level 0 DFD that conforms well to the automated "over learned" human abilities to process information (Shiffrin & Schneider, 1977). The CIPIT rules are based on highly scrutinized and replicated seminal research that strongly supports certain pervasive elemental characteristics germane to displaying information in a manner that is most easily perceived and understood (high clarity). Howard (1983); Lachman, Lachman, & Butterfield (1979); and Oborne (1985) detail and summarize many key works related to the CIPIT rules. Their work provided a genesis point that structured this investigation of CIPIT related research and culminated in the detailed CIPIT-based diagramming rules presented in appendix A (level 0 DFD oriented rules that are broadly applicable). The CIPIT related works pertain to: 1. reducing perceived uncertainty (increase clarity) by decreasing the amount of information and/or alternatives Shannon, Hick, Hyman, Miller (late 40's - mid 50's); 2. enhancing understanding (increase clarity) by catering to automated human processing abilities--for example, gridlike structures are well-suited to automated human abilities--Mowbray & Rhoades, Fitts & Switzer, Neisser, Sternberg, Egeth, Shiffrin & Schneider, Chase & Simon, Wiedenbeck (early 50's - late 80's); 3. denoting relatedness by grouping together 'like' symbols (increase clarity) as indicated by the long-standing Gestalt proximity and similarity principles (early 20's - present); 4. increasing the speed and quality of text/label comprehension (increase clarity) by left justifying text and by using appropriate punctuation (punctuation that aids in creating text that conforms to our syntactic and semantic constituent sentencial expectations) Fodor, Bever, & Garrett, Graf & Torrey, Anderson, and Trollip (mid 60's - present).

An experiment is carried out to compare the clarity of a DFD constructed using the CIPIT based rules (a high-clarity DFD) to an identical system modeled by a typical (low-clarity) DFD selected from a widely used text. The two main criteria used for the selection of the typical DFD were 1. it had to have high clarity relative to other typical DFDS (comparatively high clarity based on CIPIT rules) and 2. it had to model a well-known system so that subjects would share equal familiarity with the system depicted. Prior to the final test, extensive test development was carried out via 4 pilot tests, detailed subject

feedback, and consultation with other measurement and design experts. Clarity was measured quantitatively by comparing the two DFDs via a 19-item objective test administered to two groups. One group received the lowclarity typical DFD. The other group received the high-clarity CIPIT based DFD. The test questions were identical for the two groups. Each test was scored by two different methods. Both methods yielded the same results--results supporting the main hypothesis that the CIPIT-based DFD should enable subjects to answer more questions correctly compared to the typical DFD. Qualitative clarity information was gathered via 6 likert scale items. All results strongly support the utility of the CIPIT-based rules (refer to tables 1 and 2 below).

This study represents both an original synthesis and a first empirical investigation analyzing the clarity of level 0 DFDs. Given the broad empirical foundation supporting the DFD construction rules and the strong positive findings here; many diagramming techniques may benefit and expand upon this research.

Table 1

| | | | | | | Pooled | Var Est. | Welch-Aspin | Var.Est. |
|---|---|---|---|---|---|---|---|---|---|
| Scoring Method & Group | # of Cases | Mean | Stan. Dev. | F Val | 1-tail Prob. | t Val | Degr Free | t Val | Degr Free |
| Partial Scoring Grp1 Cipit-based Grp2 typical | 11<br>12 | 15.661<br>13.180 | 0.683<br>1.654 | 5.87 | 0.0045 | 4.62 | 21 | 4.77 | 14.90 |
| Total-Scoring Grp1 Cipit-based Grp2 Typical | 11<br>12 | 13.545<br>10.500 | 0.934<br>1.784 | 3.65 | 0.0255 | 5.06 | 21 | 5.19 | 16.90 |

TAble 2

| | Group 1 | Cipit-Based | Group 2 | Typical |
|---|---|---|---|---|
| (1-very poor/little to 5-very good/much | Mean | Stan. Dev. | Mean | Stan. Dev. |
| DFD Clarity Rating | 3.727 | 0.786 | 3.500 | 0.674 |

| | | | | |
|---|---|---|---|---|
| DFD Ability to Descr. Sys. | 4.182 | 0.751 | 3.750 | 0.754 |
| DFD Exposure | 2.182 | 1.079 | 2.167 | 0.389 |
| Checking Exposure | 1.909 | 1.221 | 2.000 | 1.348 |
| DFD not Clear Response | 0.545 | 0.820 | 1.833 | 2.167 |
| Time -in minutes | 26.545 | 5.973 | 27.083 | 5.823 |

REFERENCES

NOTE: Fourteen references are not listed due to space limitations, but are available upon request.


Abrahami, A. "The Evolving Computer Environment," *Management Science* (37:6), 1993, pp. 12-16.

Adler, M. "An Algebra for Data Flow Diagram Process Decomposition," *IEEE Transactions on Software Engineering* (14:2), 1988, pp. 169-181.

Anderson, J.R. *Language, Memory, and Thought,* Halsted Press Division of Wiley, New York, NY, 1976.

Anderson, J.R. *Cognitive Psychology and its Implications*, W.H. Freeman, San Francisco, CA, 1980.

Bersoff, E. H. & Davis, A. M. "Impacts of Life Cycle Models on Software Configuration Management," *Communications of the ACM* (34:8), 1991, pp. 105-118.

Byrnes, J.P. & Guthrie, J.T. "Effects of Prior Knowledge Structure on Textbook Chapter Search," *Contemporary Educational Psychology* (17:1), 1992, pp. 830.

Canfora, G., Cimitile A., De Carlini, U. "Reverse Engineering and Data Flow Diagrams in the ADA Environment," *North Holland Microprocessing and Microprogramming* (30), 1990, pp. 357-364.

Capron, H.L. *Systems Analysis and Design,* Benjamin/Cummings, Menlo Park, CA, 1986.

Chase, W.G. & Simon, H.A. "The Mind's Eye in Chess," In W.G. Chase (Ed.), *Visual Information Processing*, Academic Press, New York, NY, 1973.

Chen, M.J. & Chung, C.G. "Preventive Structural Analysis of Dataflow Diagrams,"*Information & Software Technology* (34:2), 1992, pp. 117-130.

Chen, M., Nunamaker, J.F. & Weber, E.S. "Computer-Aided Software Engineering: Present Status and Future Directions," *Data Base*, Spring 1989, pp. 713.

Coad, P. & Yourdon, E. *ObjectOriented Analysis* (2nd Ed) Yourdon Press, Prentice Hall, Englewood Cliffs, NJ, 1991.

Dao, K., Comer, J.,& Rodjak, D. "CIM Flows from Data Flow Diagrams," *Manufacturing Systems* (9:7), 1991, pp. 67-72.

DeGrace, P. & Stahl, L. H. *Wicked Problems, Righteous Solutions,* A Catalogue of Modern Software Engineering Paradigms, Yourdon Press,Prentice Hall, Englewood Cliffs,NJ, 1990.

Demarco, T. *Structured Analysis and System Specification*, Prentice Hall, Englewood, NJ, 1979.

France, R.B. "Semantically Extended Data Flow Diagrams: A Formal Specification Tool," *IEEE Transactions on Software Engineering* (18:4), 1992, pp. 330-346.

Gane, C. & Sarson, T. *Structured Systems Analysis: Tools and Techniques*, IST, Inc., New York, NY, 1977.

Gore, M. & Stubbe, J. W. *Elements of Systems Analysis* (3rd & 4th Ed.), Wm. C. Brown Publishers, Dubuque, IA, 1983 & 1988.

Guthrie, J.T., Britten, T., & Barker, K.G. "Roles of Document Structure, Cognitive Strategy, and Awareness in Searching for Information," *Reading Research Quarterly* (26), 1991, pp. 300-324.

Hendee, W.R., Wells, P. (Eds.), *The Perception of Visual Information* , Springer-Verlag, New York, 1993.

Howard, D. V. *Cognitive Psychology*, MacMillan, New York, NY, 1983.

Jain, H.K. & Purao, S. "Distributed Application Development: SDLC Revisited," *Information and Management* (20), 1991, pp. 247-254.

Kendall, J.E. & Kendall, K.E. *Systems Analysis and Design* , Prentice Hall, Englewood, NJ, 1988.

Kung, C. "Process Interface Modeling and Consistency Checking," *Journal of Systems & Software* (15), 1991, pp. 185-191.

Kuo,F. "A Methodology for Deriving an EntityRelationship Model Based on a Data Flow Diagram," *Journal of Systems & Software* (24:2), 1994, pp. 139-154.

Larsen, T.J. & Naumann, J.D. "An Experimental Comparison of Abstract and Concrete Representations in Systems Analysis," *Information and Management* (22:1), 1992, pp. 29-40.

Lachman, R., Lachman, J.L., & Butterfield, E.C. *Cognitive Psychology and Information Processing,* Erlbaum, Hillsdale NJ, 1979, pp. 88-129.

Liu, S. "A Formal Requirements Specification Method Based on Data Flow Analysis," *Journal of Systems Software*(21), 1993, pp. 141-149.

Lowe, R.K. "Search Strategies and Inference in the Exploration of Scientific Diagrams," *Educational Psychology* (9:1), 1989, pp. 27-44.

Mahmood, M. A. "Systems Development Methods--A Comparative Investigation," *MIS Quarterly* (11:3), September 1987, pp. 293-311.

Martin, J. & McClure, C. *Structured Techniques for Computing* , Prentice Hall, Englewood Cliffs, NJ, 1985.

Martin, M.P. *Analysis and Design of Business Information Systems* , Macmillan, New York, NY, 1991.

Newell, A., & Simon, H.A. *Human Problem Solving,* Prentice Hall, Englewood Cliff, NJ, 1972, pp. 791-809.

Nitko, A.J. *Educational Tests and Measurement an Introduction* , Harcourt Brace Jovanovich Inc., New York, NY, 1983.

Oborne, D.J. *Computers at Work a Behavioural Approach,* John Wiley and Sons Ltd, New York, NY, 1985.

Powers, M.J., Cheney, P.H., & Crow, G. *Information Systems* : *Basic Development Concepts* (2nd ed.), Boyd and Fraser, Boston, MA, 1990.

Protsko, B.L.,Sorenson, P.G., Tremblay, J.P. & Schaefer, D.A. "Towards the Automatic Generation of Software Diagrams," *IEEE Transactions on Software Engineering* (17:1), 1991, pp. 10-21.

Richeter, G., & Maffeo, B. "Toward a Rigorous Interpretation of ESML Extended Systems Modeling Language," *IEEE Transactions on Software Engineering* (19:2), 1993, pp.165-180.