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ABSTRACT

This research emerged from an effort to develop a theory of computer anxiety relevant to beginning adult learners in a range of university disciplines. To this end, the first step was to design and refine an instrument which was reliable and valid for this population. The development of the "a priori" model of computer anxiety used in this study followed this procedure: a pilot study with first year teacher trainees (N=101) using CARS (Computer Anxiety Rating Scale); an inspection of items in other anxiety instruments from previous research; a literature search in anxiety theory, leading to substantitive hypotheses of factors likely to contribute to computer anxiety; and generation of factors (constructs) and items considered to have face validity for these factors. The instrument consisted of 111 items divided into four parts or subscales: (A) Gaining Initial Computing Skills; (B) Sense of Control; (C) Computer Self-Concept; and (D) State Anxiety in Computing Situations. The validity of the model was tested on a sample of 794 undergraduate students from four disciplines of a university in the western region of metropolitan Sydney, Australia. Evidence suggested that there may be 10 factors underlying anxiety towards computers for beginning users. However, a more parsimonious model was identified using CFA (confirmatory factor analysis) analyses of the data. In particular, the results supported the existence of one second (higher) order factor for each of Parts A and D. As for Parts B and C, there was strong support for one substantive factor in each case, with negatively worded items forming a separate "method factor." A summary is provided of first- and second-order factors for each section of the instrument. Four tables illustrate data. (Contains 15 references.) (MAS)

Definitely not just anot'‌er computer anxiety instrument: The development and validation of CALM: Computer Anxiety and Learning Measure.

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Despite the proliferation of instruments designed to measure computer anxiety which emerged in the mid- to late- 1980's (a function of the recognition that all was not well with the public response to mass availability of computerised technology), there were none that were specifically designed for the beginning adult user in a university setting. Furthermore, none presented a detailed analysis of the range of constructs, both situation-specific to the gaining of initial computing skills, and more general psychological constructs such as sense of control, self concept and state anxiety, which the authors believe define computer anxiety. The present research, therefore, emerged from an effort to develop a theory of computer anxiety relevant to beginning adult learners in a range of university disciplines. To this end, the first step was to design and refine an instrument which was reliable and valid for this population, and which would test the substantive hypotheses proposed. Both exploratoy and confirmtory factor analyses were used to analyse the data.

Overview of the Process of Instrument Design

The development of the a priori model of computer anxiety used in the present study followed this procedure:

* A pilot study with first year teacher trainees (N= 101) using CARS (Computer Anxiety Rating Scale, Rosen, Sears & Weil, 1987a and b).

* An inspection of items in other anxiety instruments from previous research (e.g., Chu & Spires,1991; Heinssen, Glass & Knight, 1987; Loyd & Gressard, 1984; Meier, 1988; Simonson, M. R., Maurer, Montag-Torardi, & Whitaker, M. 1987; Speilberger, Gorsuch, & Lushene, 1970)

* An extensive search of the literature in anxiety theory, leading to a substantive hypothesis of factors (constructs) likely to contribute to computer anxiety.

* Generation of factors (constructs), and then items, considered to have face validity for these factors (face validity was evaluated by two other independent raters).

The original instrument which was designed consisted of 111 items divided over four parts or subscales(see below) and comprised twelve factors in total. The factors hypothesised were as follows:

Part A: Gaining Initial Computing Skills

Defined by four factors related to anxiety about: Learning about the Basic Functions of Computers; Performance/Competence with Computers; Handling Computer Equipment; and Receiving Feedback on Computer Competence.

Part B: Sense of Control

As there is debate in the literature about whether a negative factor, as such, can be measured by negatively worded items, yet research into personality clearly supports the existence of positive and negative perceptions of control and self concept, two alternative approaches were tested in this subscale and the following (i.e., Parts B and C).

In the first instance, two factors defining Sense of Control were hypothesised; Positive and Negative Cognitions (or self-talk) about being able to master computers. In the second approach, a model positing the existence of one substantive factor and a "negative item method effect" was tested.

Part C: Computer Self-Concept

In the research literature on general self concept, it is strongly argued that, rather than representing a substantive factor, negatively worded items merely contain an artefact. For the sake of consistency, however, the same approach was adopted in this subscale as in the previous one. In other words, both a single factor and a two factor model with regard to self-Concept about one's proficiency with computers were tested.

Part D: State Anxiety in Computing Situations

This subscale was designed with two components - a cognitive and an affective.

The cognitive component consisted of two factors - Worry and Distractability. The affective component was also made up of two factors - Happiness (positive affect) and Physiological Symptoms (negative affect).

The final Computer Anxiety and Learning Measure (CALM) derived from both EFA's and CFA's in the present study comprised 65 items. Ten first-order factors provided a good fit to the data. Two second-order factors explained the correlations between the four oblique factors in Parts A and D (Gaining Initial Computing Skills and State Anxiety in Computing Situations, respectively).

Method

The validity of the model in the present study was tested on a sample (794) of undergraduate students from four faculties (Education, Health, Arts/Social Sciences, and Business and Technology) of a university in the western region of metropolitan Sydney, Australia.

Both exploratory (EFA) and confirmatory (CFA) factor analyses were employed with the data from the present study. Although the structure of the model of computer anxiety used in this investigation was specifically defined a priori, it was considered worthwhile using EFA to explore possible alternative models.

Using LISREL VII, first-order factor models were specified by fixing parameters in three design matrices: LAMBDA X, a matrix of factor loadings; PSI, a factor variance/covariance matrix that shows relations among the factors; and THETA DELTA, a matrix that contains error/uniqueness in the diagonal. Simple models in which items were posited to represent only one factor were examined. Factors were assumed to be correlated except in the one factor plus "negative item method effect" models for Parts B and C (Sense of Control and Self-Concept, respectively), as described above.

Results

The present study produced a parsimonious model of anxiety related to learning about computers for undergraduate students.

Confirmatory factor analysis indicated that a ten factor model of computer anxiety for beginning users provided an adequate fit to the data from the present investigation. However, for two sub-scales (Gaining Initial Computer Skills and State Anxiety in Computing Situations), single higher-order factors were able to explain much of the variance in the first-order factors, and also provided a good fit to the data.

The purpose of higher-order CFA is to explain covariation among first-order factors with higher-order factors (and the correlation among first-order factors). In the present study, HCFA was accomplished by fixing factor covariances in the PSI matrix to be zero, and using the first-order factors to define an additional second-order factor. A single second-order factor was posited to represent the covariation among the four first-order factors in each of Parts A and D of the CALM instrument.

To the extent that the higher-order model fits the data nearly as well as the first-order model, the former is supported (Marsh & Richards, 1987).

Goodness-of-fit Indices

In the present study, a number of indices were taken into account in deciding what would constitute an adequate goodness-of-fit: the parameter estimates (LAMBDA X, PSI and THETA DELTA) were examined in relation to the non-substantive model and to permissible values (such as non-negative variances); and chi-square values for alternative models were compared and subjective evaluations made in terms of whether statistically significant values were acceptable. A further subjective index of adequate fit is the chi-square/df ratio. In this context, a number of researchers suggest that the value of what may be accepted will increase in proportion to the sample size and does not reflect on the adequacy of the model (Wheaton, 1987; Marsh, Balla, and McDonald, 1988). Therefore, in the present study, the relative values of the chi-square/df ratios for each model tested were compared, and the lowest ratio considered optimal. Finally, the Target Coefficient goodness-of-fit index developed by Marsh and Hocevar (1985) for higher-order factor models was applied. This is the ratio of the chi-square of the first-order model to the chi-square of the more restrictive model. In this context, Marsh and hocevar point out that the Target Coefficient increases as the number of parameters estimated in the higher-order model increases.

In relation to the higher-order models, the chi-square value for the first-order model will always be larger than that for the corresponding second-order model in which there are more parameters estimated (Marsh & Richards, 1987).

The following are the separate results for each of the four subscales within the CALM instrument (Parts A, B, C, D):

Part A: Gaining Initial Computing Skills

Defined by four factors related to anxiety about: Learning about the Basic Functions of Computers; Performance/Competence with Computers; Handling Computer Equipment; and Receiving Feedback on Computer Competence.

The criteria for determining how many factors to rotate were that factors approximate simple structure as much as possible while providing a close fit to the data and be supported by a strong substantive/ theoretical base.

A principal components factor analysis with oblique rotation produced a four factor solution that explained 52.1% of the systematic covariance among the 32 items. The first four unrotated factors accounted for 40%, 6.5%, 3.3%, and 2.5%, respectively.

The first factor, Competence/Performance Anxiety, consisted of 14 items (items 3, 4, 5, 6, 7, 9, 20, 21, 22, 26, 27, 29, 31, 33). The items defining this factor relate to anxiety associated with one's real and perceived competence with computers.

The second factor, Equipment Anxiety, consisted of 5 items (items 14, 16, 28, 30, 35). The items defining this factor relate to anxiety about using specified computerised equipment.

The third factor, Feedback on Computer Competence, consisted of 5 items (items 37, 38, 39, 40, 41). The items defining this scale relate to feelings of anxiety generated by receiving feedback on one's computer skills.

The fourth factor, Learning about the Computer, consisted of 8 items (items 1, 8, 10, 11, 12, 15, 24, 25). The items defining this factor relate to anxiety associated with learning about computers in a class situation.

Alpha coefficients for each of the computed scales were as follows:

Factor 1: .92
Factor 2: .80
Factor 3: .88
Factor 4: .89

Item deletion:

One of the main objectives of the model testing was to develop an instrument that was both robust psychometrically and was parsimonious for ease of administration and interpretation. For the latter reason, particularly, factors comprising no more than 6 or 7 items were aimed for in the instrument refinement process. Items whose factor loadings were between .3 and .4 were critically evaluated in terms of their contribution to the substantive model under consideration. Similarly, items whose contribution to the corrected item-total correlation was low (and whose deletion would, therefore, improve the standardised item alpha coefficient) were scrutinised for possible deletion, pending a confirmatory factor analysis.

LISREL VII was used to perform confirmatory factor analyses on the data using the same theoretical factor structure derived from the initial substantive model from which items had been generated. Out of interest, this was compared with the EFA's to determine which items could clearly be deleted in the final instrument.

Four models were tested for Part A Gaining Initial Computing Skills:

The first model was the four factor model submitted to EFA using exactly the same (32) items.

Using the results of the first model, the second model extracted those items whose THETA DELTAS were below .5 (indicating that 50% or more of the variance was error or uniqueness that could not be explained by the factor it was intended to measure); whose WEIGHTED LEAST SQUARES ESTIMATES (factor loadings) were above .6; whose modification indices were low and/ or indicated that an item was loading strongly on more than one factor; and that had greatest face validity (one of the strongest criteria for selection). This left 22 items as follows:

Factor 1: 3, 4, 6, 21, 26, 29, 33

Factor 2: 14, 28, 30, 35

Factor 3: 37, 38, 39, 40, 41

Factor 4: 1, 11, 12, 15, 24, 25

As the results from the first model indicated a high correlation (PHI> .6) between each of the four factors and as it was hypothesised that all items in Part A logically related to aspects of gaining initial computing skills in formal class settings, two additional models were tested.

The third model, therefore, was a unidimensional one in which all items from the previous (second) model were included as one factor.

The fourth model predicted that there was one higher-order factor, Gaining Initial Computing Skills, in addition to four first-order factors (Learning about the Basic Functions of Computers; Performance/Competence with Computers; Handling Computer Equipment; and Receiving Feedback on Computer Competence). This model was believed to be the most appropriate fit as it was in keeping with the substantive grounds for the items in Part A, and would also account for the correlation between factors, referred to earlier.

Table 1 Four models of Part A: Gaining initial computer skills

	Goodness-of-fit indicators				
	Chi2	df	AGFI	RMSR	chi2/df ratio
Model 1	1543.75	428	.935	.057	3.61
Model 2	569.44	203	.968	.046	2.81
Model 3	2294.85	209	.873	.108	10.99
Model 4	587.60	205	.967	.047	2.87

Note:
Model 1: Four factors (32 items)
Model 2: Four factors (the "best" 22 items)
Model 3: One factor (22 items)
Model 4: Higher-order factor plus four first-order factors

Using the chi-square/degrees of freedom ratio as the strongest indicator, the "best" fit to the data is Model 2 (ratio of 2.8) with the AGFI very strong at .968. (Note: the large sample size inflates the chi-square along with the large number of parameters estimated). However, on substantive grounds, namely, the correlation between factors, model 4 is preferred. The chi-square/degrees of freedom ratio in this case is only marginally higher (ratio of 2.87) with the AGFI still very high at .967. Support for this model is also provided by the high correlation between the first-order factors (ranging from .65 to .94) as well as the Target Coefficient of .97 (the ratio of chi-square of the first-order factor model to the chi-square of the higher-order factor model), which indicates that the more restrictive higher-order model provides an excellent fit to the data.

Part B: Sense of Control

Two hypothesised factors here were Positive and Negative Cognitions (or self-talk) about being able to master computers.

Exploratory factor analyses were conducted on the 20 items defining this scale. Using an oblimin rotation, two clear factors were identified which accounted for 49.5% of the variance. The first factor, Negative Sense of Control, consisted of those 11 items which represented negative cognitions.

The second factor, Positive Sense of Control, consisted of those items (items 1, 7, 16, 18, 19, 20) which represented positive cognitions. All items in both factors had factor loading between .57 (the lowest) and .81 (the highest).

Interestingly, a third factor emerged from the oblique rotations which isolated three items that did not appear to have strong face validity although they were related to the Control construct. The factor loadings averaged .56 for these three items. It was decided, therefore, to delete them from the scale altogether.

In an attempt to arrive at a parsimonious model, factor one was reduced by 5 items as it was felt that those items remaining (items 3, 5, 9, 12, 13, 17) were sufficiently strong, both psychometrically and substantively, to define the factor.

Cronbach alphas for each of the factors were as follows:

Factor 1: .85 (after deletion of superfluous items)

Factor 2: .89

It is worth noting that the factor correlation matrix for Part B showed a moderate .44 correlation between the two factors. For this reason, it was decided to test a unidimensional model as well as a possible "negative item method effect".

As with Part A, LISREL VII was used to perform confirmatory factor analyses on the data in Part B. Four models were fit to the data:

The first model used the factor structure derived from the initial substantive model from which items had been generated, and which had been supported by exploratory factor analyses, albeit somewhat "pruned". In this model, two substantive factors were posited.

The second model examined the possibility that there was only one factor underlying both the negative and positive items, that is, it was unidimensional.

The third model was the same as the first except that PHI and THETA DELTA were set as symmetrical and fixed, and the LAMBDA's and THETA DELTA's freed, in order to test if all the negative items would load on a separate (method) factor. In this model, two factors were posited, one "substantive" one on which all items were allowed to load, and a "negative item" method factor for negative items only.

The fourth model examined the possibility of one substantive factor and the "negative item method effect" as correlated uniquenesses. This was done by allowing the THETA DELTAS for the negatively worded items to be correlated. (Note: this is an alternate method to model three).

Table 2 Four models of Part B: Sense of Control

	Goodness-of-fit indicators				
	Chi2	df	AGFI	RMSR	chi2/df ratio
Model 1	204.73	53	.976	.049	3.86
Model 2	1445.40	54	.833	.144	26.77
Model 3	161.86	48	.979	.042	3.37
Model 4	99.00	39	.984	.033	2.54

Note:
Model 1: Two factors (12 items)
Model 2: One factor only (12 items)
Model 3: Two factors: one substative factor and one method "artefactor"
Model 4: One factor plus method effect (correlated errors)

Clearly, model two is a very poor one with a chi-square/degrees of freedom ratio of 26.77, an AGFI of .833 RMSR of .144. Using the criteria of parsimony and the chi-square/degrees of freedom ratio as the strongest indicators, the "best" fit to the data is Model 4 (chi-sq/df ratio of 2.54) with the AGFI very high at .984. (Note: the large sample size inflates the chi-square along with the large number of parameters estimated).

It could also be argued, however, that the two factor model provided a very good fit to the data. As it was pointed out earlier, there is a substantive argument for being able to distinguish between those individuals who have either a positive or a negative sense of control with regard to learning computing skills. In this regard, model one provides further support for retaining two separate dimensions of the Sense of Control items with the relatively moderate correlation (PHI = .52) between the latent factors, (i.e., only 27% (.52 squared) of their variation being shared).

PART C: Computer Self-Concept

Exploratory factor analyses were performed on the 20 items in this scale. It was originally hypothesised that there would be two factors in this scale; one which measured a Positive Computer Self-Concept ("I am good at computing"), and the other which measured a Negative Computer Self-Concept ("I am no good at computing").

Two clear factors emerged which accounted for 53% of the variance. The first was that of a Positive Computer

Self-Concept which consisted of 12 items. The items defining this factor related to perceptions of confidence and self-efficacy with regard to computing.

The second factor which had been hypothesised, was that of Negative Computer Self-Concept. The 8 items in this factor related to lack of confidence and belief in one's ability with computers.

It is worth noting that the factor correlation matrix showed a very high correlation between the two factors (.75).

As the scale was considered too long (20 items) to be included in a battery of tests, it was decided to delete those items in both factors which did not have strongest face validity. Those that were retained (11 items) had factor loadings of between .45 and .94 (the majority were greater than .6). Items that were retained were:

Factor 1: 6, 7, 15, 16, 17, 19

Factor 2: 1, 4, 5, 9, 11

Interestingly, alpha coefficients for the reliabilities of the two hypothesised factors in their reduced form were as follows:

Factor 1: .91

Factor 2: .86

LISREL VII confirmatory factor analyses were performed on Part C. Four models were fit to the data:

The first model predicted that there were two factors as in the exploratory factor analyses in which the factors were allowed to be correlated.

The second model was a unidimensional factor estimation with all the THETA DELTA's freed.

The third model estimated two factors: One a "real" or substantive factor; the other a "method" factor which accounts for the negatively worded items. Here PHI and THETA DELTA were set at symmetrical and fixed, with each of the LAMBDA's and THETA DELTA's freed. This allowed for all the negative items to load on one separate method factor.

The fourth model estimated one factor allowing for the errors/uniquenesses to be correlated for the negatively worded items. (Note: this is an alternative method to model three)

Table 3 Four models of Part C: Computer Self-Concept

	Goodness-of-fit indicators				
	Chi2	df	AGFI	RMSR	chi2/df ratio
Model 1	165.53	43	.978	.041	3.85
Model 2	387.71	44	.950	.068	8.80
Model 3	114.91	39	.983	.034	2.94
Model 4	110.46	34	.982	.033	3.25

Note:
Model 1: Two factors (11 items)
Model 2: One factor only (11 items)
Model 3: two factors: one substative factor and one method "artefactor"
Model 4: One factor plus method effect

Both models 3 and 4 provide excellent fits to the data. Model 3 has greater parsimony than model 4 as fewer parameters are estimated and the degrees of freedom are higher, therefore. Furthermore, the chi-sq/df ratio is the lowest of all four models.

In essence, therefore, there appears to be only one self-concept factor in Part C, with negatively worded items constituting a "method effect". This is supported by the high correlation between the two hypothesised factors (PHI = .84), indicating that approximately 71% (.84 squared) of the variation between the latent factors is shared.

PART D: State Anxiety in Computing Situations

This subscale was designed with two components - a cognitive and an affective one.

The cognitive component consists of two factors - Worry and Distractability. The affective component is also made up of two factors - Happiness (positive affect) and Physiological Symptoms (negative affect).

Exploratory factor analyses were performed on the 30 items in this scale. As hypothesised, four interpretable factors were identified which explained 57.7% of the systematic covariance among the items. these were named according to the items defining the factors.

Factor one, Worry, consisted of ten items (items 4, 7, 10, 18, 20, 21, 22, 25, 27, 28) which represent thoughts that are synonymous with the "worry" which occurs specifically in computing situations. Factor loadings for all of the items ranged from .42 to .73.

Three items (7, 22, 25) were considered for deletion, namely those which had a factor loading of below .59 (each of these also cross-loaded on at least one other factor) and whose face validity were doubtful.

The reliability of the factor was .88 with all ten items included. After deletion of the weaker items, the reliability increased to .90.

Factor two, Physiological Symptoms, consisted of six items (items 1, 2, 3, 12, 13, 23) which related to the range of physiological symptoms typically associated with anxiety. The reliability of this factor was .86. Factor loadings for the items ranged between .42 and .81. One item, "Upset" (item 23), cross-loaded on another factor (Worry) to which it was logically related. Although the reliability of the factor suffered marginally by its deletion (dropping to .85), it was felt desirable that there be no ambiguity, especially for the purpose of confirmatory factor analyses.

Factor three, Distractability, consisted of three items (items 5, 6, 11) which related to inability to concentrate while in a computing situation. One item, "Irritable" (item 11), was found to be ambiguous (cross-loading on two other factors), which reduced the alpha reliability coefficient. Standardized item alpha rose from .74 for the three items to .81 after the deletion of the weak item. Note: In the revision of this factor, three new items relating to distractability have been added to further extend this important dimension of state anxiety.

Factor four, Happiness, consisted of eleven items (items 8, 9, 14, 15, 16, 17, 19, 24, 26, 29, 30) which related to a positive affective state while using computers. As it was considered desirable to reduce the number of items in this factor to be more consistent with the others in this subscale, five items (items 8, 9, 16, 17, 24) with the lowest factor loadings were deleted. The remaining items had factor loadings between .73 and .85. Standardised item alpha was somewhat reduced from .95 for the full set of items to .93 after item deletion. Nevertheless, this smaller set was considered preferable, and the reliability still robust.

Using LISREL VII , confirmatory factor analyses were conducted on the revised set of items from the exploratory factor analyses in Part D. Two models were fit to the data:

The first model predicted that there were four first-order factors in Part D, comparable to the exploratory factor analyses.

The second model predicted that, in addition to the four first-order factors in model one, there was one second- or higher-order factor.

Table 4 Two models of Part D: State Anxiety in Computing Situations

	Goodness-of-fit indicators				
	Chi2	df	AGFI	RMSR	chi2/df ratio
Model 1	345.30	164	.986	.045	2.10
Model 2	372.55	166	.985	.048	2.24

Note:
Model 1: Four factors (20 items)
Model 2: Higher-order factor plus four first order factors

Using the ratio of chi-square of the first-order factor model to the chi-square of the higher-order factor model as a criterion (Marsh and Hocevar, 1985), the value of the Target Coefficient was .93, which indicates that the more restrictive factor model provides a very good fit to the data. There was moderate to high correlation between the first-order factors (ranging from .42 to .78) which was considered sufficient to support the existence of a higher-order factor as well.

Conclusion

Evidence from the present study suggested that there may be ten factors underlying anxiety towards computers for beginning users. However, a more parsimonious model was identified using CFA analyses of the data. In particular, the results supported the existence of one second (higher) order factor for each of Parts A and D. This was not surprising, as all items defining the first-order factors in these sub-scales related logically to the general construct for each section. Although these results for the Gaining Initial Computing Skills and the State Anxiety in Computing Situations constructs (Parts A and D), based on the four factor models, support the multi-dimensional nature of these computer anxiety constructs, it is implied by the more parsimonious higher-order models in each case that it may be valid to subsume the different dimensions under a broader construct of General Anxiety in Gaining Initial Computing Skills. Thus it is argued that, for administration of the CALM instrument, the use of a single "threshold" scores for these single higher-order constructs may be justified (cf. Shek, 1993).

As for the Sense of Control and Self Concept constructs (Parts B and C), there was strong support for one substantive factor in each case, with negatively worded items forming a separate "method factor". In the case of Part B, however, there may well be a valid argument for the existence of two separate factors. Follow up study is required to test the construct validity of the alternative models.

In effect, therefore, the model of computer anxiety derived from the CFA analyses can be summarised in the following way:

PART A:

Four first-order factors -

* Learning about the Basic Functions of Computers; *
* Performance/Competence with Computers;
* Handling Computer Equipment; and
* Receiving Feedback on Computer Competence

One second-order factor -

* General Anxiety in Gaining Initial Computing Skills

PART B:

One factor? -

* Sense of Control

Two factors? -

* Positive and Negative Sense of Control

PART C:

One factor -

* Computer Self-Concept

PART D:

Four first-order factors -

* Worry
* Distractability
* Happiness
* Physiological Symptoms

One second-order factor -

* General State Anxiety in Computing Situations

The generalisability of the model of computer anxiety presented in this study has yet to be demonstrated.

While the original sample was representative of the composition of the population of interest, namely, undergraduate students undertaking initial study of computing (or - gaining initial computer literacy skills through university coursework), the model needs to be replicated with another sample. This has been undertaken in a small follow-up study of 40 students enrolled in an introductory computing course with the Faculty of Arts and Social Sciences conducted two years later, the results of which are currently being analysed (McInerney, McInerney, Lawson & Jacka, 1994).

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