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A revised learning transfer system inventory: factorial replication and validation

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The learning transfer system inventory (LTSI) is an empirically derived self-report 16-factor inventory designed to assess individual perceptions of catalysts and barriers to the transfer of learning from work-related training. Although a good deal of research has been done addressing various dimensions of the LTSI's construct validity, minor discrepancies in factor solutions in several studies together with problematic fit of some items suggest that further construct validity research is needed. Using data collected in 17 countries and utilizing 14 different language versions of the LTSI, the research objectives for this research were to (1) determine the number and nature of common factors involved to account for the pattern of correlations among the measured variables in LTSI version 3 using exploratory factor analysis (EFA) and (2) test via confirmatory factor analysis the validity of the factorial structure of the LTSI that emerged from the EFA and scale refinement efforts. Results provided strong support for the five- and 11-factor structure of the program-specific and training-general domains of a 48-item LTSI.

Keywords: learning transfer; personnel training; test validity

Transfer of learning is defined as the extent to which knowledge, skills and abilities learned in work-related training are generalized and maintained on the job. Reviews of learning transfer research over the years (e.g. Baldwin and Ford 1988; Baldwin, Ford, and Blume 2009; Ford and Weissbein 1997) consistently point to the complexity of the learning transfer process: it is a dynamic one that moves from pre-training experiences to the acquisition of knowledge and skills, to the capability to apply new learning to job-related tasks, to the application of learning to tasks and activities beyond those that were initially targeted by the training. This complex process is influenced by a variety of factors, a 'transfer system' (Holton 2003), which includes individual differences and perceptions (e.g. motivation, efficacy beliefs, expectations), factors within the training event (e.g. job relevant content, appropriate

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learning activities) and contextual factors (e.g. supervisor and co-worker support, group norms about change, rewards). The implication is that learning transfer can only be understood and fostered by examining a relatively complete system of influences.

Although a good deal of progress has been made in our understanding of some dimensions of the learning transfer process such as training design factors (Bell and Kozlowski 2008; DeRouin, Fritzsche, and Salas 2004; Ford and Kraiger 1995), knowledge of other factors including trainee perceptions and contextual factors has lagged behind (Baldwin et al. 2009). We contend that transfer practice and research would benefit from a more concerted effort to investigate, compare and report a core set of individual, training design and contextual factors known to be critical for successful transfer.

This view prompted the development of the learning transfer system inventory (LTSI) more than 15 years ago. The development of this tool grew out of the recognition that a wide variety of measures were being used in transfer research to assess various factors affecting learning transfer. Not only there was little overlap in instruments used from one study to another but there was also wide variation in the quality of measurement tools being used. Very few measurement tools had undergone rigorous development and testing and, as a result, the psychometric qualities of many instruments were open to question (Holton, Bates, and Ruona 2000). Still today there are differences in measurement instruments and instrument quality that continue to limit our ability to generalize findings across studies and draw valid conclusions about the factors affecting learning transfer in the workplace.

The LTSI is an empirically derived self-report inventory designed to assess individual perceptions of catalysts and barriers to the transfer of learning from work-related training. The goal in the ongoing development of the LTSI has been to provide researchers and practitioners with an instrument that contains a core set of rigorously developed and validated transfer system scales reflecting those elements critical to promoting effective learning transfer in the workplace.

Research with the LTSI

Research done with the LTSI in recent years has provided evidence of the convergent and divergent validity of the LTSI scales (Holton, Bates, and Bookter 2007) as well as evidence of the instrument's criterion-related validity. Studies have shown LTSI scales to be correlated with self-reported learning transfer (Devos et al. 2007), intent to transfer (Holton and Bates 2011) and perceived utility of training (Ruona et al. 2002). Other studies have provided evidence of LTSI scales' capacity to predict learning and post-training knowledge retention (Myers 2009), motivation to transfer (Seyler et al. 1998), changes in job performance as a result of learning transfer (Bates, Kauffeld, and Holton 2007; Bates et al. 2000; Fitzgerald 2002), organizational performance (Bates et al. 2007) and organizational innovation (Bates and Khasawneh 2005). Finally, research suggests the LTSI can distinguish different configurations of learning transfer systems across organizations (Holton, Chen, and Naquin 2003) and training types (Khasawneh, Bates, and Holton 2006).

The current version of the LTSI (version 3) emerged from a research program initiated in 1997 with version 1, a 63-item instrument that assessed nine constructs (see Holton et al. 1997). Version 1 was originally constructed with data from a sample of workers in a petro-chemical manufacturing plant in the southern US.

Following this research, several revisions were made to version 1. New items to measure additional scales were added and the instrument was fit to the conceptual structure of the HRD Research and Evaluation Model (Holton 1996). The result was version 2, an instrument expanded to 112 items and measured 16 constructs.

The scales in version 2 were created to assess factors affecting a trainee's ability to transfer learning, motivation to transfer and key transfer environment factors. The 16 constructs represented two distinct construct domains: 11 constructs represented factors affecting a specific-training program (program-specific factors) and five factors were classified as training-general factors because they represented perceptions of factors extending across training programs (training-general factors). The constructs in these two domains represent four categories of elements consistent with those in the HRD Research and Evaluation Model: (1) secondary elements, (2) ability/enabling factors, (3) motivation factors and (4) work environment factors.

Exploratory factor analysis (EFA) of the version 2 instrument (Holton et al. 2000) conducted with a large and diverse sample yielded version 3 of the LTSI, a 68-item instrument that reproduced the same 16 constructs. Subsequent to this analysis, and in an effort to more clearly define and assess some of the constructs, an additional 21 items were added to create version 3 of the LTSI, an 89-item instrument.

Validation research with different language versions

In the last 10 years, version 3 has been translated into 17 languages. Validation studies with several of the translated versions have provided evidence supporting the 16-factor structure. For example, studies in Belgium with the French version (Devos et al. 2007), Germany (German version) (Bates, Kauffeld, and Holton 2007), Greece (Greek version) (Holton and Bates 2011) and Thailand (Thai version) (Yamnill 2001) using a consistent EFA methodology (common factor analysis with oblique rotation) produced factor solutions equivalent to both the 11-factor structure of the program-specific domain and the 5-factor structure of the training-general domain identified in the Holton et al. (2000) study.

Other validation studies have produced factor solutions that, although consistent with these findings, show minor factorial variations. A study using the Jordanian/Arabic version concluded that a 12-factor structure was optimal for the program-specific domain (Khasawneh et al. 2006). Ten of the 12 factors matched those in the Holton et al. (2000) program-specific domain. The other two factors included a three-item factor that combined items from the personal capacity and negative personal outcomes scale. This scale showed marginal loadings (.33–.46) and a low reliability estimate ($\alpha = .48$). The twelfth factor was an unstable two-item factor also with a low reliability estimate ($\alpha = .55$). Analysis of the training-general domain produced a six-factor solution in which the performance coaching scale separated into two factors reflecting different modes of feedback (verbal advice and active assistance). Another EFA construct validation study using the Taiwan/Chinese version (Chen, Holton, and Bates 2006) showed, for the program-specific domain, an 11-factor structure in which 10 factors matched the Holton et al. (2000) structure. However, a new program-specific factor emerged which combined items associated with the transfer design and opportunity to use learning constructs. There were also several items from the opportunity to use scale that reflected problematic fit. Exploratory factor analysis of the training-general domain showed a five-factor structure highly consistent with the five identified in the Holton et al. (2000) study. An EFA with data collected with the Ukrainian translation (Yamkovenko, Holton, and Bates 2007) produced 11 interpretable factors that paralleled the 11 factors in the program-specific domain found by Holton et al. (2000). Analysis of this domain also pointed to problematic fit with items from the opportunity to use, personal capacity and personal outcomes positive scales. Exploratory factor analysis of the training-general domain items produced results that matched the factor structure of the training-general domain in the Holton et al. (2000) study.

In summary, exploratory factor analyses with eight translated versions of the 89-item version 3 LTSI have provided results generally consistent with the expected 16-factor structure. However, minor discrepancies in factor solutions in some studies together with problematic fit of particular items suggest that further construct validity research is needed more to fully establish the psychometric soundness of the LTSI. In addition, without exception, the factorial validity of the LTSI in published studies has been examined using only an EFA approach. In light of the deficiencies associated with EFA approaches (e.g., Bollen 1989), it is clear that a confirmatory factor analysis (CFA) approach would provide a much more powerful test of factorial validity.

This study was designed to address these issues and had two primary objectives: (1) to test the number and nature of common factors needed to account for the pattern of correlations among the measured variables in the 89-item LTSI using EFA; (2) to cross-validate via CFA the validity of the factorial structure of the LTSI that emerged from the EFA and scale refinement efforts.

Method

Instrument

Version 3 of the LTSI is an 89-item self-report survey designed to assess individual perceptions of barriers and catalysts to the transfer of work-related learning. Each item is rated on a five-point Likert-type scale ranging from one (strongly disagree) to five (strongly agree).

Sample

A total of 5990 participants drawn from a variety of organizations provided data for this study. The sampling strategy was purposive insofar as the data were collected from individuals who had recently attended or attending organization-sponsored training programs. Data were collected over a period of 10 years by the authors or by other researchers or practitioners who used the LTSI. Respondents completed the LTSI in either paper form or through an electronic survey administered at the conclusion of training. The sample included data collected in 17 countries using 14 different language versions of the LTSI. Respondents represented a variety of industries including health care, banking, insurance, information technology, municipal and state governments, manufacturing, engineering, health, higher education, telecommunications, petroleum, retail, insurance, hotel and transportation. They came from a variety of work roles such as nurses, high-school teachers, mechanical and electrical engineers, technicians, manufacturing operators, secretaries, mid- and upper-level management, customer service and customer relations, housekeeping, sales, direct service staff/mental health, supervisors and junior and senior managers. Respondents attended a wide range of training programs that addressed a variety of knowledge and skill elements including those related to interpersonal communication, technical specialties (e.g. engineering), administration, counseling, information and computer technology, supervision, management and leadership and ethical decision making. The descriptive data available for the sample are shown in Table 1.

The data in this study included data from previously published studies and unpublished data. This approach provided a large, heterogeneous sample which minimized the impact sample specific variance might have on factorial results and increased statistical power. As EFA is a large-sample procedure and is prone to error in small samples, the most generalizable and replicable results are obtained with large diverse samples (Costello and Osborne 2005). In addition, the underlying statistical theory for CFA assumes that elements in the sample covariance matrix are equal to the population values. For this reason, large sample sizes are necessary for proper estimation in CFA (Kahn 2006). From a factorial validation perspective, a large sample provides the opportunity to subdivide the sample and yet retain two large working sub-samples, allowing one sub-sample for EFA and the second for CFA of the EFA results. This approach is widely viewed as more useful than doing a single analysis with the entire sample (Floyd and Widaman 1995).

Analysis

Exploratory factor analysis and item reduction

Data from the full sample were randomly divided into two sub-samples (A and B) of approximate equal size in preparation for subsequent analysis. Data from sub-sample A were used for the initial EFA and the data from sub-sample B were used for CFA. Random assignment was important for cross-validation purposes in order to control for differences across the sub-samples that might affect the factor structures within the separate sub-samples.

Exploratory factor analysis using common factor analysis (principle axis factoring) is generally regarded as preferable to principle components analysis (Costello and Osborne 2005). Because the LTSI factors are assumed to be correlated, oblique rotation (direct oblimin) was selected as the rotation method. The analysis was conducted using SPSS version 19. Exploratory factor analysis is a data-driven methodology in which no a priori specification of the number of factors is made. Nevertheless, it is not uncommon for researchers using EFA to have expectations about the latent structure that may emerge. That was certainly the case in this study. However, the subjectivity and uncertainty associated with the various criteria used for factor extraction in EFA often lead to unreliable factor solutions. In an attempt to address this shortcoming several criteria were used to guide decisions on the number of factors to extract. This included the eigenvalue >1 criterion, the scree plot to determine the point at which the slope of eigenvalues approached zero, and the number of variables that had strong factor loadings ($\geq .50$) on a factor. At least three variables per factor were required to identify common factors that are stable (Comrey 1988).

In addition to EFA, analysis was directed at evaluating items in an effort to refine and focus scale content while adequately assessing the construct domain. Item evaluation and retention decisions were based on both strict criteria as well as the expert judgment of the authors based on their relatively long research history with

Table 1. Descriptive data.

Country	*N*	LTSI language	Industry type(s)	Training type	Trainee type
Canada	287	French/Quebec	–	–	–
China*	590	Mandarin Chinese	Hotel	Customer relations, computer skills and technical skills	Non-managerial front-line employees (e.g. front desk, housekeeping)
Germany*	674	German	Electrical engineering, mechanical engineering, construction, financial services, social services, health, pharmaceuticals, automotive manufacturing, IT,	–	–
Greece	430	Greek	Banking	Technology, management and customer service	Managers and customer service representatives
Iceland	120	Icelandic	–	–	–
Iran	195	Farsi	Banking	Administration, financial management, human resources, management and strategic change	Supervisors and managers
Ireland	150	English	Financial services	Leadership development	Junior and senior managers
Jordan*	325	Arabic	Manufacturing, high-tech and banking, insurance	Interpersonal skills, customer relations, new employee	

(*continued*)

Table 1. (*Continued*).

Country	*N*	LTSI language	Industry type(s)	Training type	Trainee type
				orientation, webpage design, computer skills, safety and accident and compensation	
Malaysia	236	Bahasa Malaysian	–	–	–
The Netherland	142	Dutch	–	–	–
Portugal*	489	Portuguese	Industrial manufacturing, business and financial services and insurance	Management, technology and interpersonal skills	–
South Africa	151	English	Banking	Financial services, customer service and management	Managers and customer service representatives
Taiwan*	698	Taiwan Chinese	Education, civil service, electronics, insurance, petroleum, social work, retail, transportation and telecommunications	Computer skills, curriculum development, customer, service, mid-level management, new employee orientation, customer service, quality management, safety, spiritual, systems operations, accounting, train-the-trainer and machine maintenance	–
Turkey	398	Turkish	–	–	–

(*continued*)

Table 1. (*Continued*).

Country	*N*	LTSI language	Industry type(s)	Training type	Trainee type
Ukraine*	300	Ukrainian	Health, higher education, retail and agriculture	Sales, marketing, computer skills, teaching skills, extension services, customer service, medical equipment and pharmaceutical	
UK	184	English	–	–	–
US	621	English	Mental health, high technology, mental health counseling, secondary education administration and counseling	Technology training, configuring technology, administration, trouble-shooting hardware and software, ethical decision making, positive behaviour interventions, functional assessment, classroom interventions and curriculum-based measurement	Direct service staff (mental health), service engineers, high-school counselor and administrators
Total 5990					

Note: *Indicates published study. Empty cells indicate the descriptive data were not available from the researchers.

the instrument. Criteria for item deletion included cross-loading $\geq .32$ (Costello and Osborne 2005). In cases where an inter-item correlation was more than moderate ($r > .69$, Westgard 1999), the item with the lower factor loading was removed. Scale reliability estimates were also considered in making item retention decisions. Although it is desirable to maximize coefficient alpha, there are limitations with this as a strategy for item retention as it can increase scale homogeneity, increase item redundancy and reduce the breadth and dimensions of a construct assessed by a measurement scale (Coste et al. 1997). Therefore, expert judgment was used to identify those items that would enhance heterogeneity, avoid item redundancy in a scale and strengthen the practical significance of the scales. Enhancing item heterogeneity within a factor can contribute to validity across cultural settings: if all the items in a scale are similar and a given item elicits discrepant responses across cultures then item redundancy could increase measurement error (Boyle 1991).

Confirmatory factor analysis

Exploratory factor analysis is most appropriately used to explore a data set and researchers are cautioned against drawing substantive conclusions based on EFA results (Floyd and Widaman 1995). Confirmatory factor analysis, on the other hand, allows the testing of theoretically or empirically based hypotheses about the number of factors and which variables correspond to which factors. Among factor analytic procedures CFA is considered a powerful test of factorial validity and is seen as the approach most capable of confirming hypothesized factor structures (Bentler 1989; Byrne 1993). Therefore CFA, using AMOS 7, was used to confirm the hypothesized factor structure that emerged from the EFA and scale refinement efforts. In CFA, the LTSI factor structure was tested for fit with the observed covariance structure of the measured variables. Confirmatory factor analysis also allows the testing of alternative models and can thus be used to further refine instruments. Since initially specified models nearly always fail to provide acceptable fit, the models must be respecified, tested again using the same data and then the final model cross-validated with another sample (Anderson and Gerbing 1988). Therefore, two sub-samples were created for the CFA (CFA1 and CFA2) from sub-sample B data. Confirmatory factor analysis 1 was used to test the EFA results and to suggest model respecifications, if needed. Confirmatory factor analysis 2 was set aside to test the final model.

Separate CFA models were run for the program-specific domain and the training-general domains. The CFA models depicting the 11-factor structure of the program-specific domain and the five-factor structure of the training-general domain hypothesized that (1) responses to the items in these domains could be explained by 11 and five factors, respectively, (2) each item would have a non-zero loading on the LTSI factor it was designed to measure and zero loadings on all other factors, (3) the 11 factors in the training-specific domain would be correlated as would the five factors in the training-general domain, and (4) measurement error terms would be uncorrelated.

Model fit was assessed via examination of the chi-square likelihood ratio (χ^2) and several descriptive goodness-of-fit indices. Lower values of chi-square indicate better fit and should be non-significant. However, in large samples the use of chi-square as an index of fit is contraindicated. Therefore, it was important to use descriptive fit indices to judge acceptable model fit that were not adversely affected by sample size.

For this study, CFA models were judged to have acceptable fit if the incremental fit index (IFI), the comparative fit index (CFI) and the Tucker-Lewis index (TLI) equaled or exceeded the cutoff value of .95 recommended by Hu and Bentler (1999). For all of these indices, values close to one indicate very good fit. The root mean square error of approximation (RMSEA) was also examined with values falling below .5 indicating a close fit of the model in relation to the degrees of freedom.

Results

Exploratory factor analysis and scale refinement

Using data from sub-sample A, the factor structure of the 89-item LTSI was assessed using EFA. The raw data were used as input. List-wise deletion was used for missing data. The 11-factor program-specific domain (63 items) and the five-factor training-domain (26 items) were factor analysed separately.

Program-specific domain

The measure of sampling adequacy (MSA), a measure of the data set's appropriateness for factor analysis, was .94 for the program-specific data. Values $\geq$.90 are considered strong and indicate the data are suitable for factoring (Hair et al. 1998). The initial EFA for this domain resulted in a 12-factor solution that explained 60.97% of the common variance. However, examination of the solution indicated a two-item factor which did not meet the three-item per factor minimum required for stable factors. Closer examination of the two items that loaded as a separate factor showed these to be negatively worded items that had created problematic fit issues in previous validation studies of the LTSI. As a result, the two problematic items were deleted and the EFA was run again.

The MSA for the subsequent EFA was also .94. The results indicated an exceptionally clean and interpre table 11-factor structure in which all the items loaded on the anticipated factors. The solution explained 60.28% of the common variance. Table 2 shows factor loadings for all of items in the program-specific domain. Inter-scale correlations (Pearson's) and reliability estimates are shown in Table 3. Reliability estimates ranged from .71 to .85 all in the acceptable range (Nunnally and Bernstein 1994).

Subsequent to the EFA additional analysis was directed at evaluating scale items and, where possible, refining scale content to reduce item homogeneity, better reflect the underlying construct, and where reasonable, to reduce scale length. Shorter scales are generally preferable from both a research and applied practice perspective because they increase organizational and respondent acceptance, minimize completion time and diminish respondent fatigue. For most scales, the three highest loading items were retained as this is the minimum needed for stable scales (Comrey 1988). However, there were two noteworthy exceptions. First, item 46 (.67) was selected for the supervisor opposition scale even though its pattern coefficients were lower than several other items. Other items with higher pattern coefficients (item 34/.80, item 38/.74 and item 42/.73) were not retained because they were closely similar in meaning to one of the other retained items (items 36 or 35). Item 41 (.73) was not retained because it was less consistent with the conceptualization of the supervisor opposition construct. Item 46 was selected because it was consistent with the construct definition and enhanced item heterogeneity in a desirable direction. Second, for the personal

Table 2. Exploratory factor analysis rotated factor pattern and pattern coefficient for items in the program-specific domain.

Item	Opportunity to use	Supervisor opposition	Supervisor support	Personal outcomes positive	Personal outcomes negative	Personal capacity	Learner readiness	Peer support	Motivation to transfer	Transfer design	Content validity
56	.53	−.09	−.01	−.02	−.01	.08	.00	.10	.01	.14	−.08
55	.51	−.08	−.01	.01	−.03	.01	.02	.07	−.16	.13	−.06
51	.50	−.13	−.01	−.02	−.02	−.01	−.01	.11	−.08	.18	−.03
60	.46	−.01	−.06	−.04	−.02	−.01	.06	.03	.00	.08	−.08
62	.46	−.01	−.04	−.03	.00	−.06	.05	.03	.02	.02	−.10
50	.44	−.05	−.07	.03	−.05	.03	.02	.02	−.09	.07	−.22
19	.34	.14	−.04	−.10	.03	−.34	.10	.06	−.07	−.04	.01
36	−.02	.83	−.04	.01	−.02	−.01	.01	−.01	.00	−.02	−.02
35	.01	.82	−.02	.01	−.02	−.02	.00	−.02	−.03	−.01	.00
34	−.02	.80	−.01	.03	.02	−.02	.00	.01	−.05	−.02	−.02
38	.03	.74	.01	.00	−.05	.02	.00	−.03	.03	.01	.03
42	−.05	.73	.08	−.03	.04	.01	.02	.01	.08	.00	−.06
41	−.03	.73	.01	−.03	.02	.05	.01	−.02	.02	.00	−.03
46	−.03	.67	.02	−.01	−.09	.02	−.01	.01	−.03	−.06	−.07
45	−.01	.66	−.02	.03	−.03	.05	−.01	.01	.03	.05	.05
44	.03	.40	.00	−.03	.00	.07	−.02	.03	−.04	.06	.08
33	−.04	.06	−.78	.01	−.06	−.07	.01	.02	−.02	−.05	−.07
32	−.07	.04	−.77	.00	−.08	.00	.01	−.01	−.03	−.03	−.07
43	.02	.05	−.71	−.06	.03	−.01	.02	−.04	.03	.05	−.01
40	.01	−.06	−.70	−.03	.03	.08	−.01	.08	−.07	.02	.04
39	.01	.00	−.69	−.04	−.05	−.02	.02	.02	−.04	.02	.04
37	.08	−.13	−.66	−.02	.05	.07	−.01	.08	.03	.06	.06
8	−.03	.02	−.01	−.86	.06	.04	.03	.02	.05	.02	.01
7	−.02	−.04	−.02	−.82	.06	−.02	.03	.02	−.03	.00	.00
6	.01	.04	−.03	−.78	.00	.03	.02	−.07	−.03	−.03	−.08
22	.03	.01	−.03	−.64	−.23	−.04	−.03	−.04	−.01	.00	−.06
16	−.01	.06	−.06	−.62	−.11	.04	.00	.05	.03	.03	−.03
15	.04	−.07	−.06	−.46	−.07	−.02	.02	.12	−.12	.07	.08

(*continued*)

Table 2. (*Continued*).

Item	Opportunity to use	Supervisor opposition	Supervisor support	Personal outcomes positive	Personal outcomes negative	Personal capacity	Learner readiness	Peer support	Motivation to transfer	Transfer design	Content validity
18	.04	−.03	−.07	−.34	−.09	−.03	.00	.17	−.20	.07	.09
23	−.01	.08	−.06	−.01	−.76	−.04	.00	−.01	.00	.01	.01
21	.03	.05	.00	.01	−.76	.09	−.01	−.02	−.02	−.04	−.04
14	−.02	−.01	.00	−.04	−.64	.04	.02	−.02	.04	−.03	−.02
24	.01	−.03	−.06	−.01	−.53	−.05	.03	.15	.00	.01	.01
17	.07	.08	.02	−.30	−.37	.05	.00	−.03	−.02	−.01	−.03
11	.08	.13	−.02	−.05	.07	.69	−.01	−.03	.07	−.11	−.03
12	.11	.12	−.08	−.01	−.02	.67	.01	−.08	.05	−.09	−.02
20	−.02	.02	−.02	−.02	−.05	.65	.03	−.04	.01	−.04	.00
26	−.05	.10	−.02	.01	−.11	.39	.00	.01	−.06	−.01	.04
27	−.14	.00	.08	−.04	−.06	.36	.01	.12	−.06	.08	.06
25	.33	.13	.00	−.09	−.03	−.34	.06	.11	−.09	−.01	.01
10	−.02	−.01	.00	.03	.02	−.04	.77	.00	.04	−.04	−.03
9	.06	−.05	.00	−.08	.01	.02	.61	.03	−.09	−.07	−.01
1	.02	.04	.01	−.05	.00	.02	.57	.00	−.11	−.06	−.03
13	−.04	−.01	−.04	.04	−.04	.04	.48	.01	.05	.16	.03
29	.01	.07	−.05	−.04	.01	−.02	.03	.81	.03	−.04	−.06
28	.01	−.01	.04	−.02	.03	.00	.01	.73	−.06	.02	−.01
30	.02	.02	−.03	.01	−.10	.00	.00	.69	−.01	.02	−.04
31	.07	−.04	−.14	.01	.00	−.02	.03	.51	.04	−.04	−.07
4	.05	−.04	.02	.02	−.01	−.03	.05	−.04	−.76	.01	.01
3	.03	.00	−.01	−.03	−.02	.02	−.01	.01	−.70	.00	−.06
2	−.02	.03	−.05	−.03	.02	.00	.09	−.01	−.66	−.01	−.01
5	−.05	.01	−.05	−.01	.04	.00	−.03	.06	−.58	.05	−.02
54	−.02	.02	−.04	−.04	.06	−.03	.00	.02	.03	.75	−.05
55	.06	.02	.00	−.04	.02	−.07	.02	.00	−.05	.68	.00
53	.03	.01	−.05	.01	−.01	−.04	.05	.02	.00	.64	−.07
52	.14	−.01	−.04	.00	.02	−.01	.00	−.01	−.14	.54	−.06

(*continued*)

Table 2. (*Continued*).

Item	Opportunity to use	Supervisor opposition	Supervisor support	Personal outcomes positive	Personal outcomes negative	Personal capacity	Learner readiness	Peer support	Motivation to transfer	Transfer design	Content validity
59	.19	−.01	−.02	.01	−.04	−.03	.07	−.03	−.05	.40	−.20
58	.22	−.04	.00	−.05	−.07	−.03	.08	.00	−.12	.29	−.19
48	−.01	−.01	.01	−.05	−.03	.00	.02	.06	−.01	.03	−.79
47	.02	−.01	.00	−.02	−.01	.03	.05	.08	.02	.07	−.62
49	.03	.02	−.07	−.01	−.02	−.03	.01	.04	−.17	.09	−.56

Note: Initial eigenvalues and amount of variance explained (in parentheses): opportunity to use: 13.11 (21.50); supervisor opposition: 7.84 (12.86); supervisor support: 3.09 (5.07); personal outcomes positive: 2.19 (3.58); personal outcomes negative: 1.90 (3.12); personal capacity 1.80 (2.95); learner readiness: 1.69 (2.78); peer support: 1.57 (2.56); motivation to transfer: 1.32 (2.16); transfer design: 1.17 (1.92); content validity: 1.09 (1.78). Factor loadings of the items that comprise each scale are shown in shaded form. $N = 2599$.

Table 3. Inter-scale correlations and reliability estimates (Cronbach's alpha).

Scale	*n*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Content validity	2986	.80															
2 Transfer design	2995	.46*	.80														
3 Personal capacity	2992	−.13*	−.21*	.78													
4 Opportunity to use	2978	.50*	.55*	−.29*	.79												
5 Motivation to transfer	3004	.36*	.38*	−.15*	.41*	.78											
6 Learner readiness	2993	.33*	.25*	−.07*	.30*	.38*	.71										
7 Supervisor support	2996	.34	.27*	.00	.33*	.29*	.26*	.84									
8 Supervisor opposition	3001	−.02	−.16*	.44*	−.20*	−.03	.03*	.06*	.83								
9 Peer support	3008	.38*	.36*	−.11*	.43*	.37*	.28*	.44*	−.04*	.83							
10 Personal outcomes positive	2989	.27*	.21*	.07*	.29*	.36*	.28*	.42*	.21*	.37*	.83						
11 Personal outcomes negative	3000	.18*	.01	.26*	.07*	.13*	.12*	.31*	.37*	.25*	.45*	.81					
12 Performance self-efficacy	3000	.28*	.34*	−.14*	.35*	.30*	.23*	.24*	−.07*	.25*	.16*	.06*	.75				
13 Transfer effort performance expect	3004	.31*	.42*	−.15*	.40*	.44*	.23*	.26*	−.13*	.37*	.23*	.06*	.40*	.75			
14 Performance outcome expect	3005	.31*	.28*	−.02*	.36*	.34*	.23*	.43*	.06*	.38*	.50*	.23*	.28*	.40*	.72		
15 Performance coaching	3007	.30*	.24*	.06*	.28*	.24*	.22*	.46*	.13*	.37*	.39*	.30*	.22*	.25*	.46*	.85	
16 Resistance to change	2997	−.10*	−.11*	.41	−.20*	−.00	−.03*	−.06*	.43*	−.14*	.06*	.16*	−.08*	−.10*	−.05*	−.04*	.80

Note: $*p < .05$ (two-tailed); scale reliability estimates (Cronbach's alpha) are on the diagonal. Scales in the training-general domain are shaded. Data from sub-sample A.

outcomes positive scale, item 22 (.64) was selected over item six (.78) because the wording of the former more effectively broadened the scales' conceptual reach. In sum, the selection of both item 46 and item 22 represented efforts to increase item heterogeneity and the breadth of measurement of their respective scales while maintaining a minimum of items.

Training-general domain

The MSA for the training-general domain data was .90 indicating its suitability for factor analysis. The EFA for these items resulted in an exceptionally clean and interpretable five-factor solution in which all the items loaded on the anticipated factors. The solution accounted for 56.08% of the common variance. Again, scale refinement efforts in this domain led to the retention of three items per scale. Table 4 shows the pattern coefficients for all items that ranged from .00 to .83. Reliability

Table 4. Exploratory factor analysis rotated factor pattern and pattern coefficients for items in the training-general domain.

Item	Performance coaching	Resistance to change	Performance self-efficacy	Transfer effort performance expectation	Performance outcome expectations
81	.83	.02	−.07	−.03	−.07
80	.81	−.03	−.07	−.04	−.04
86	.80	.00	.01	.01	−.01
89	.55	.04	.12	−.06	.03
88	.47	−.14	.12	.06	.20
79	.44	.03	.03	−.07	.20
87	.30	−.07	.26	−.01	.12
77	.01	.82	.03	.00	.05
76	.02	.77	.02	.05	.02
74	.11	.70	−.02	.04	.04
73	−.08	.57	−.01	−.05	.04
78	.16	−.37	.06	−.04	.15
75	.20	−.33	.01	−.02	.17
83	−.01	.06	.73	.06	−.02
84	.00	.00	.72	.02	.07
85	.05	.01	.68	−.07	−.02
82	−.08	−.09	.63	−.17	−.10
66	.00	.00	.01	−.71	−.01
71	.01	−.02	.02	−.69	.07
65	.04	.00	.02	−.67	−.05
69	.00	−.01	.03	−.66	.07
67	.03	.03	.00	−.01	.69
68	.05	.09	.02	−.23	.57
72	.21	.13	.05	−.01	.52
70	.03	−.03	.01	−.20	.49
64	.08	.26	−.01	−.01	−.37

Note: Initial eigenvalues and amount of variance explained (in parentheses): performance coaching: 6.71 (25.82); resistance to change: 2.74 (10.53); performance self-efficacy: 2.41 (9.28); transfer effort performance expectations: 1.56 (6.00); performance outcome expectations: 1.16 (4.45). Factor loadings of the items that comprise each scale are shown in shaded form. $N = 2894$.

estimates (Cronbach's alpha) ranged from .72 to .85, all in the acceptable range (Nunnally and Bernstein 1994) (see Table 3).

The EFA findings suggested an 11-factor structure for the program-specific domain and a five-factor structure for the training-general domain with all the items loading together on the correct factors. All scales were reduced to three items and displayed acceptable reliability estimates. As seen in Table 3, the estimated correlations between the factors were low to moderate ranging from .00 to .55 with an average inter-scale correlation of .24. Overall, the EFA results strongly support the 16-factor structure of the LTSI.

Confirmatory factor analysis

One of the limitations of EFA is that it cannot assess the extent to which a hypothesized model fits the data. This must come from a CFA approach (Bollen 1989). In this study, two sub-samples were created for the purpose of CFA. The first sub-sample, CFA1, was used to test the EFA results containing only three-item scales and to indicate any model respecifications in the event of poor fit. The second sub-sample, CFA2, was created to test the final model emerging from CFA1. For both these analyses, separate CFA models were run for the factors in the program-specific domain and those in the training-general domain, yielding four separate sets of CFA results.

CFA1 program-specific results

Confirmatory factor analysis 1 results for the program-specific domain ($n = 1484$) suggested the 11-factor model was an acceptable fit for the data: χ^2 ($df = 440$) $= 1448.67$, $p < .001$; $\chi^2/df = 3.29$; CFI = .95; TLI = .94; IFI = .95; RMSEA = .04. A significant chi-square was anticipated given the large sample but the χ^2/df was below the five benchmark suggested by Schumacker and Lomax (1998). All of the fit indices were at the .95 cutoff suggested by Hu and Bentler (1999) with the exception of the TLI which was below the .95 level.

CFA1 training-general results

Confirmatory factor analysis 1 results for the training-general domain ($n = 1484$) indicated the five-factor model was a good fit for the data: χ^2 ($df = 80$) $= 203.22$, $p < .001$; $\chi^2/df = 2.54$; CFI = .98; TLI = .97; IFI = .98; RMSEA = .03. A significant chi-square was anticipated given the large sample but the χ^2/df was below the five benchmark. All of the fit indices were above the more rigorous cutoff of .95 suggested by Hu and Bentler (1999).

Given the acceptable fit of the hypothesized models for both the program-specific and training-general models and with no empirical or theoretical basis for model respecification, no effort was made to further improve these models. Therefore, the CFA2 sample data were used to cross-validate these results.

CFA2 program-specific results

Confirmatory factor analysis2 results for the program-specific domain ($n = 1467$) suggested the 11-factor model was an acceptable fit for the data: χ^2 ($df = 440$)

=1471.38, $p < .001$; $\chi^2/df = 3.34$; CFI = .95; TLI = .94; IFI = .95; RMSEA = .04. A significant chi-square was anticipated given the large sample but the χ^2/df was below the five benchmark. Again, with the exception of the TLI (.94), all of the fit indices were at the cutoffs suggested by Hu and Bentler (1999).

CFA 2 training-general results

Confirmatory factor analysis2 results for the training-general domain ($n = 1467$) indicated the five-factor model was a good fit for the data: χ^2 ($df = 80$) = 280.64, $p < .001$; $\chi^2/df = 3.51$; CFI = .97; TLI = .96; IFI = .97; RMSEA = .04. A significant chi-square was anticipated given the large sample but the χ^2/df was again was below the five benchmark. All of the fit indices were above the cutoffs suggested by Hu and Bentler (1999). The fit statistics for all CFA are shown in Table 5.

Although chi-square for all CFA was significant, it has been argued that the chi-square goodness-of-fit statistic is contraindicated as a measure of fit with large samples because it is directly affected by sample size (Kahn 2006; Maruyama 1998). As a result, some have suggested using χ^2/df estimates with those between one and five indicating good fit (Schumacker and Lomax 1998). The χ^2/df estimates for all models fell within this range. Examination of the other fit indexes for both the 11-factor program-specific model and the five-factor training-general model indicated a good fit of the hypothesized models to the data. Both CFA1 and 2 demonstrated that responses to the items in the program-specific and training-general domains could be explained by 11 and five factors, respectively. Items specified to measure common underlying factors in both domains showed relatively high-factor pattern coefficients on the respective factor with zero loading on all other factors. For the CFA2 data these ranged from .57 to .89 with an average factor pattern coefficient of .73 for the program-specific factors. Factor pattern coefficients for the training-general factors ranged from .57 to .85 with an average of .73.

The tested models also hypothesized items would have zero loadings on all other factors and that the measurement error terms were uncorrelated. These hypotheses were supported. Finally, the models tested were recursive, hypothesizing and confirming inter-factor correlations among the 11 factors in the program-specific domain and five factors in the training-general domain.

Table 5. Goodness-of-fit statistics for the 11-factor program-specific and 5-factor training-general models for CFA1 and CFA2 samples.

Sample and Model	n	χ^2	df	χ^2/df	TLI	IFI	CFI	RMSEA (CI)
CFA1 11-factor program-specific	1484	1448.67	440	3.29	.94	.95	.95	.039 (.037–.042)
5-factor training-general	1484	203.22	80	2.54	.97	.98	.98	.032 (.027–.038)
CFA2 11-factor program-specific	1467	1471.38	440	3.34	.94	.95	.95	.037 (.038–.042)
5-factor training-general	1467	280.64	80	3.51	.96	.97	.97	.044 (.039–.049)

Note: TLI = Tucker-Lewis Index; IFI = incremental fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; CI = confidence interval.

To avoid model misinterpretation, both factor pattern and factor structure coefficients should be interpreted in CFA studies involving correlated factors. When factors are correlated as in the models tested in this study, it is always the case that the factors for which the pattern coefficients are constrained to zero will have structure coefficients not equal to zero (Graham, Guthrie, and Thompson 2003). It is therefore important to examine both of these components to avoid misinterpretation of the functioning of single variables or the content or meaning of the factors themselves. In this study, examination of the standardized pattern coefficients and the factor structure coefficients (r^2) for both the program-specific and training-general factors showed that none of the variables had correlations on factors with fixed zero pattern coefficients higher than the structure coefficients for factors on which the pattern coefficients were freed (tables containing these data are available from the lead author upon request). This strongly suggests there are no issues with regard to the functioning of single variables or the content or meaning of the factors themselves.

Discussion and implications

The aim of this research was to examine the dimensionality of items used to assess individuals' perceptions of organizational learning transfer systems. The results provide strong support for the 16 factors structure of the LTSI. In the initial sample, EFAs indicated the items in the program-specific domain of the LTSI were best summarized by 11 underlying constructs and items in the training-general domain were best summarized by five underlying constructs. Although the factors were correlated, none of the estimated correlations between the factors were excessively high ($>.85$). As seen in Table 3, the estimated correlations between the factors were low to moderate ranging from .00 to .55 with an average inter-scale correlation of .24. These data support the discriminant validity and the distinctiveness of the factors measured by the LTSI and these are consistent with the previous construct validation research done with the LTSI.

Two separate CFAs were used to test hypotheses about how many three-item factors exist in the program-specific and training-general domains of the LTSI, which variables correspond to which factors, and whether the hypothesized factor structure of the program-specific and training-general two domains provided a good fit to the data. Results from CFA1 provided strong evidence that the hypothesized models were an acceptable fit to the data. The data did not indicate an empirical or theoretical basis for model respecification. As a result, no effort was made to further improve these models. They were, however, tested with a second CFA sample with equivalent results. In addition, relatively low inter-factor correlations among both domains of factors suggest there is little overlap among the scales and that each assesses a unique construct. Finally, the sample data used in these analyses came from a wide range of organizations, training programs and participants, and included data from 14 different language versions of the LTSI collected in 17 different countries. The heterogeneity of these data, together with the analytic results, argues strongly for the generalizability and stability of the factorial structure of the LTSI.

This research also produced a much shorter version of the LTSI (48 vs. 89 items) while maintaining the instrument's essential characteristics. It is hoped that the shorter version will increase organizational and respondent acceptance, minimize completion time and diminish respondent fatigue, and provide a more practical, easier-to-use, and more accessible instrument for organizations, training practitioners and researchers.

Although the 16-factor model of learning transfer system characteristics was supported in this study, further research is needed to examine whether the factor structure fits data from different groups equally well. Multiple group CFA comparing, for example, the factor structure of the LTSI across groups defined by a demographic variable (e.g. gender, ethnicity), cultural orientation, training type, organizational or individual difference variable would provide additional and important validity evidence for LTSI scores. It may also be informative to compare factor structures across groups with varying degrees of language fluency, for example, between native English speakers and second language English speakers completing the English language version of the LTSI.

Future validation research should focus on the criterion-related validity of the LTSI. Although some of this work has been done (e.g. Bates et al. 2000, 2007; Fitzgerald 2002; Myers 2009; Seyler et al. 1998) more is needed to examine the criterion-related validity for each factor of the LTSI using the latest version of the instrument.

Finally, a number of transfer system improvement interventions linked to specific LTSI scales and transfer system barriers have recently been developed. Quasi-experimental research examining how these interventions affect an organization's learning transfer system, changes in learning, job behaviour and performance and return-on-training investment would help the HRD field move beyond the question of *whether or not* training works to *why* training works and *how* the transfer outcomes and training effectiveness can be improved.

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