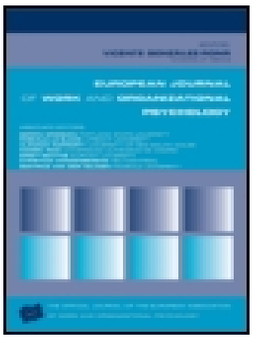

Routledge
Taylor & Francis Group

European Journal of Work and Organizational Psychology

ISSN: 1359-432X (Print) 1464-0643 (Online) Journal homepage: https://www.tandfonline.com/loi/pewo20

Competencies for virtual teamwork: Developmentand validation of a web-based selection tool for members of distributed teams

Guido Hertel , Udo Konradt & Katrin Voss

To cite this article: Guido Hertel , Udo Konradt & Katrin Voss (2006) Competencies for virtual teamwork: Developmentand validation of a web-based selection tool for members of distributed teams, European Journal of Work and Organizational Psychology, 15:4, 477-504, DOI: 10.1080/13594320600908187

To link to this article: https://doi.org/10.1080/13594320600908187

EUROPEAN JOURNAL OF WORK AND
ORGANIZATIONAL PSYCHOLOGY
2006, 15 (4), 477 – 504

Psychology Press
Taylor & Francis Group

Competencies for virtual teamwork: Development and validation of a web-based selection tool for members of distributed teams

Guido Hertel
University of Würzburg, Würzburg, Germany

Udo Konradt and Katrin Voss
University of Kiel, Kiel, Germany

The development and validation of the Virtual Team Competency Inventory (VTCI), an Internet-based measure for selection and placement of members in virtual teams, is described. Item selection was based on a conceptual model with three main categories (taskwork, teamwork, and telecooperation related KSAs) and 11 subscales. After an exploratory pilot study with 169 undergraduate students, 39 items remained in the final version of the VTCI. In the main study, 258 members of organizational virtual teams completed the VTCI and were concurrently assessed by their team managers. The results showed satisfactory reliability of the VTCI (overall alpha = .92) and good convergent and discriminant validity. The concurrent multiple validity of the VTCI was .49 for individual team members' performance. Moreover, analyses at the team-level revealed significant correlations between team effectiveness and mean, minimum (but not maximum), and variance aggregations of VTCI predictors within the teams.

The interest of organizations in teamwork continues to attract substantial research attention (e.g., Kozlowski & Bell, 2003; West, 2001). In light of the increasing globalization and technological progress, teams are now becoming

Correspondence should be addressed to Guido Hertel, Department of Psychology, Work, Industrial & Organizational Psychology, University of Würzburg, Roentgenring 10, D-97 070 Würzburg, Germany. E-mail: hertel@psychologie.uni-wuerzburg.de

Parts of this paper have been presented at the XIIth European Congress of Work and Organizational Psychology, Istanbul, Turkey (May 2005). The data of this study were part of the PhD thesis of the third author. We wish to thank Julie Lyon, Vincente González-Romá, J. H. Erik Andriessen, and an anonymous reviewer for their comments to an earlier version of the paper. We also thank Bernhard Weber and Thomas Ellwart for their support during data analyses.

http://www.psypress.com/ejwop DOI: 10.1080/13594320600908187

more and more "virtual" due to the fact that members are often dispersed across different locations and have to coordinate their work via electronic communication media such as telephone, e-mail, video-conferencing, etc. (Axtell, Fleck, & Turner, 2004; Bell & Kozlowski, 2002; Hertel, Geister, & Konradt, 2005). Virtual teams can be found in various fields, such as research and development (R&D), procurement, or customer service, and they also exist in noneconomic organizations such as virtual collaboratories in sciences (e.g., Finholt, 2002). Although exact data of the prevalence of virtual teams in organizations are difficult to obtain because the distinction between face-to-face and virtual teams is rather gradual than dichotomous (cf. Bell & Kozlowski, 2002; Hertel, Geister, & Konradt, 2005), recent estimations as well as future scenarios suggest that the number of such teams is substantial and constantly growing. For instance, a recent survey among 376 business managers from different branches in Germany (AFW, 2002) revealed that about 20% of the managers worked predominantly as a member of a virtual team, and about 40% worked at least temporarily in virtual teams. Similar trends have been reported for other countries (Duarte & Snyder, 2001; Gibson & Cohen, 2003; Hinds & Kiesler, 2002). In light of these developments, HR and management applications for virtual teams are urgently needed.

Empirical research on virtual teams has accumulated slowly in the last few years, focusing predominantly on operational issues such as leadership or the maintenance of trust and motivation (e.g., a special issue of *Organizational Dynamics* in 2003 on leadership in virtual teams; see also, for recent reviews, Gibson & Cohen, 2003; Hertel, Geister, & Konradt, 2005; Hinds & Kiesler, 2002). Issues of selection and placement of virtual team members, however, have been neglected so far, somewhat parallel to the research history of conventional teams some years ago (Stevens & Campion, 1999). Initial theoretical suggestions have been made (e.g., Blackburn, Furst, & Rosen, 2003; Ellingson & Wiethoff, 2002; Harvey, Novicevic, & Garrison, 2004), but we are not aware of any study addressing the issue of staffing virtual teams empirically.

The objective of the present study is the development and empirical validation of an Internet-based measure to assess crucial competencies for virtual team members. We first outline the theoretical model on which the instrument is based and then describe item development and a pilot study on initial construct validation. Finally, we document a validation study with existing virtual teams of a large media company in which we assessed the concurrent predictive validity of our measure, and collected first evidence of team-level aspects of staffing virtual teams.

COMPETENCIES FOR VIRTUAL TEAMS

Lipnack and Stamps (1997) defined virtual teams as "a group of people who interact through interdependent tasks guided by common purpose. Unlike

conventional teams, a virtual team works across space, time, and organizational boundaries with links strengthened by webs of communication technologies'' (p. 6). Although such early approaches seem to suggest that virtual teams are qualitatively different from conventional teams, the distinction between those two is rather fuzzy. Teams that are considered as conventional also use electronic communication media, and members of distributed teams often meet also face-to-face at least occasionally. As a consequence, consensus is now increasing that the degree of virtuality is rather a quantitative dimension of teams (relative ''virtuality''; cf. Axtell et al., 2004; Bell & Kozlowski, 2002; Hertel, Geister, & Konradt, 2005; Kirkman & Mathieu, 2005). Potential measures of relative virtuality are average spatial distance between the team members, number of working sites weighted by the number of members at the different sites, relation between electronic media use and face-to-face communication, etc. (Kirkman & Mathieu, 2005; O'Leary & Cummings, 2002). However, for reasons of simplicity, we will use ''virtual team'' throughout the text for teams with high levels of relative virtuality.

Given that the level of virtuality is only one dimension of teams, there should be a considerable overlap in needs and requirements relevant both for conventional and virtual teams. Consequently, our competency model includes four basic selection criteria that are derived from competency models for conventional teamwork. In addition, however, we include competencies that are particularly required by high degrees of virtuality in a team. Before these extensions are described, we will first briefly summarize competencies that have been discussed and demonstrated for conventional teams.

Competencies for conventional teams

Competencies are defined as learned abilities to perform a task, duty, or role in a particular work setting, integrating several types of knowledge, skill, and attitude (e.g., Roe, 2002). Although ''teamwork skills'' are demanded nearly in every job advertisement today (Allen & Hecht, 2004), it is still discussed controversially what those teamwork skills might be. Following the suggestions made by Stevens and Campion (1994, 1999) and Weaver, Bowers, Salas, and Cannon-Bowers (1997), we focus on knowledge, skills, and abilities (KSAs) rather than on personality traits or dispositions as important. Although recent work (e.g., Barrick, Stewart, Neubert, & Mount, 1998; Barry & Stewart, 1997) has demonstrated that personality-based selection criteria such as the ''Big Five'' personality factors can explain considerable variance of team effectiveness, ability-based selection has been more successful and offers more opportunities for personnel development (Stevens & Campion, 1994, 1999). Moreover, we concentrate

on individual-level attributes since the focus is how to allocate individuals on virtual teams, as opposed to aspects of team or organizational levels of analysis (Klein & Kozlowski, 2000). However, team-level analyses will be included when we compare different within-team aggregations of competencies with overall effectiveness ratings of the team.

As a basic distinction of competencies for conventional teams, we distinguish *taskwork* and *teamwork* KSAs as individual determinants of team performance (see also Stevens & Campion, 1994, 1999; Weaver et al., 1997). However, whereas Stevens and Campion include as taskwork KSAs both technical skills and "in-role" related abilities, we additionally differentiate between job expertise/technical training (e.g., programming skills of software developers) and taskwork KSAs that are related to successful performance in a more general way. According to recent meta-analyses (e.g., Schmidt & Hunter, 1998), such taskwork KSAs particularly include aspects of reliability, such as conscientiousness, integrity, and loyalty. Moreover, whereas other authors consider interpersonal and self-management KSAs as the two main aspects of teamwork skills (e.g., Stevens & Campion, 1994, 1999), we restrict teamwork competencies to interpersonal KSAs (i.e., cooperativeness and communication skills; cf. Figure 1). Self-management skills are conceptualized here as one of the aspects that are particularly relevant for teams with high degrees of virtuality where control and support by supervisors and/or colleagues is low (see also Ellingson & Wiethoff, 2002; Jarvenpaa & Leidner, 1999).

Together, our model includes three groups of competencies derived from research on conventional teams: Job expertise and professional training, taskwork KSAs predominantly related to reliability, and teamwork KSAs

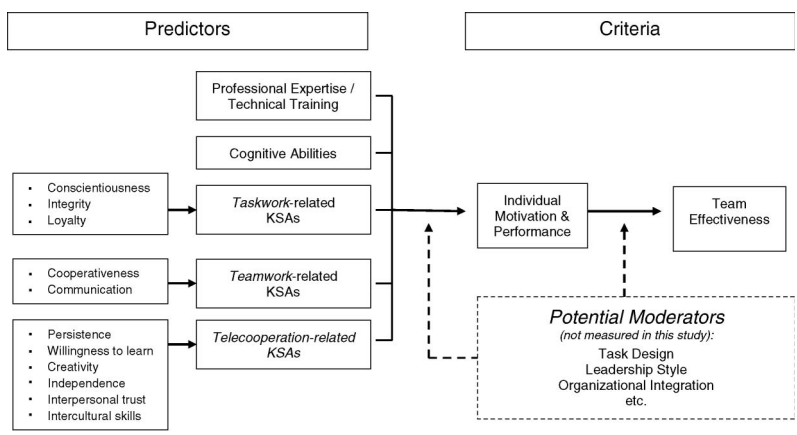

Figure 1. Predictors and criteria of the Virtual Team Competency Inventory (VTCI).

related predominantly to social aspects (cf. Figure 1). Finally, as a fourth group of predictors, cognitive abilities are included both based on theoretical considerations as well as empirical evidence with conventional teams (e.g., Barrick et al., 1998).

Competencies important for telecooperation

In addition to the competencies derived from research with conventional teams, we consider *telecooperation-related* KSAs in our model that should become particularly important with high degrees of virtuality. Based on theoretical analyses of the specific challenges of telecooperation (e.g., Duarte & Snyder, 2001; Ellingson & Wiethoff, 2002; Harvey et al., 2004; Hertel, Deter, & Konradt, 2003; Jarvenpaa & Leidner, 1999; Lipnack & Stamps, 1997) as well as own qualitative in-depth interviews with business managers of virtual teams, we considered three main groups of competencies as particularly relevant: self-management skills, interpersonal trust, and intercultural skills.

Self-management skills. Self-management KSAs are particularly required when supervisory control and social control by other team members are reduced, which is often the case in highly virtual teams (Harvey et al., 2004; Staples, Hulland, & Higgins, 1999). Self-management skills are considered here in terms of four major aspects: independence, persistence, learning motivation, and creativity. *Independence* includes the ability to plan and organize ones own activities without external support, and is highly related to self-efficacy beliefs (Bandura, 1977). Persons high on independence should be better able to cope with isolated working conditions and lack of external control. *Persistence* includes aspects of self-motivation, endurance of goal striving, and continuing activities after interruptions. Working in virtual teams often is connected with unplanned interruptions, for instance due to other commitments at the local site, so that high degrees of persistence should be positive for virtual teamwork (Warkentin, Sayeed, & Hightower, 1997). *Learning motivation* includes the intrinsic interest in new and unknown contents (in contrast to learning skills as part of general cognitive abilities). Learning motivation is particularly important for virtual teams due to the pioneering character of virtual teamwork (Duarte & Snyder, 2001). Apart from rapidly changing technological tools, virtual team members have to adapt more often to a changing environment as part of their work. Finally, *creativity* should be relevant for virtual teams for similar reasons. Due to spatial dispersion and high flexibility demands, virtual team workers compared to members of conventional teams are more often faced with new problems and challenges with few pre-existing routines that require unusual solutions and creative problem solving (Haywood, 1998). Thus, creativity should also be a crucial competency for teams with high degrees of virtuality.

Interpersonal trust. Perhaps the most frequently mentioned precondition of successful virtual teams in the literature is the development of mutual trust within the team because opportunities for mutual control are reduced when virtuality increases (e.g., Jarvenpaa & Leidner, 1999; Maruping & Agarwal, 2004). Although a number of trust building interventions are possible (and recommended) such as a face-to-face kick-off workshop (Duarte & Snyder, 2001; Warketin & Beranek, 1999), facilitation of nonjob related communication (Hofner Saphiere, 1996), or the development of team rules (Duarte & Snyder, 2001; Konradt & Hertel, 2002), the effectiveness of such interventions usually takes time. Thus, it would be helpful if team members already have a disposition to trust others that might facilitate the development of a positive team climate (Jarvenpaa & Leidner, 1999).

Intercultural KSAs. Finally, virtual teams often emerge as a consequence of general globalization strategies such as mergers and acquisitions, the development of new markets in foreign countries, etc. Therefore, members of virtual teams quite often have to cooperate with partners from other countries and cultural backgrounds (Duarte & Snyder, 2001; Ellingson & Wiethoff, 2002). Moreover, diversity in virtual teams often results from different educational, occupational, or functional backgrounds of its members when the team is implemented to create cross-sectional expertise within an organization (e.g., connecting experts from R&D, production, sales, and accounting). KSAs related to sensitivity and handling of such heterogeneity and cultural differences might thus also be an important competency for working in a virtual team.

INTEGRATED COMPETENCY MODEL

Based on the theory described above, our competency model for virtual team members includes five major groups of selection criteria (cf. Figure 1). First of all, *professional expertise and technical training* are included simply because they are mandatory to do the task at hand. However, selection criteria should not be restricted to such technical aspects but should be complemented by extrafunctional competencies. The second group of competencies includes *cognitive abilities*, which are among the best predictors of occupational success in general (e.g., Schmidt & Hunter, 1998) as well as for team effectiveness (e.g., Barrick et al., 1998). Empirical evidence for virtual teams is lacking, but there are good reasons that cognitive abilities are also important for virtual teams because the tasks of such teams are usually rather complex and require high problem solving skills (Hertel, Geister, & Konradt, 2005). It should be noted, though, that measures of cognitive abilities are often not well accepted by employees in organizational context.

This is particularly true for high status and well trained experts that are often the candidates for virtual teams.

The third group of competencies is *taskwork-related KSAs* that cover general aspects of reliability of a person. Particularly, aspects of loyalty, integrity, and conscientiousness are considered as relevant. These competencies have been proven as relevant for performance in general (e.g., Schmidt & Hunter, 1998) as well as for performance and motivation in conventional teamwork (e.g., James & Cropanzano, 1994). Although empirical evidence is lacking, we expect that these competencies should be also relevant in teams with high levels of virtuality, particularly when external and/or social control are reduced (see also Ellingson & Wiethoff, 2002; Jarvenpaa & Leidner, 1999).

The fourth group of competencies is *teamwork KSAs* that include cooperativeness and communication skills. Cooperation and conflict management skills are considered relevant because reduced personal interaction and lack of common context might increase the risk of misunderstandings and feelings of being neglected. The importance of communication skills, on the other hand, is less obvious in virtual teams because face-to-face interaction is generally reduced. On the one hand, this might lead to an increase of communication skills needed in order to develop innovative ways to maintain interpersonal connections. Indeed, in a study of health circles among teleworkers, participants stressed repeatedly that they had to be socially active rather than passive in order to prevent isolation and exclusion (Konradt, Schmook, Wilm, & Hertel, 2000). However, communication skills might also become less relevant with higher levels of virtuality in teams due to a general reduction of social interaction and a stronger task orientation (e.g., Marshall & Novick, 1995). The data of this study will shed initial light on this question.

Finally, *telecooperation KSAs* as the fifth group contain competencies that are particularly related to challenges of high virtuality in teams, such as isolated working conditions (requiring self-management-skills), lack of mutual control (requiring interpersonal trust), and cultural diversity (requiring intercultural skills). Together, the five groups of competencies are expected to predict the potential of persons for high performance in virtual teams. Moreover, we also expect these competencies to predict the potential for mobilizing high motivation as important part of performance in virtual teams. Whether this potential can be realized might of course be moderated by demands and external factors such as task design, leadership style, organizational integration, etc. (cf. Figure 1). However, in this initial study we focus on individual competencies only.

In the next section, we describe the development of the Virtual Team Competency Inventory (VTCI) as a questionnaire measure of the latter three competencies of our model: taskwork KSAs, teamwork KSAs, and

telecooperation KSAs. Professional expertise and technical training are not included because we are interested to develop a measure that can be generalized to different task contexts. Cognitive abilities were also not included due to the mentioned acceptance problems. However, the VTCI can be easily complemented by measures of technical skills and cognitive abilities. Sometimes data of cognitive abilities are already available from earlier selection and placement analyses.

QUESTIONNAIRE DEVELOPMENT

The Virtual Team Competency Inventory (VTCI) is conceptualized as a self-assessment questionnaire including 11 subscales that address taskwork KSAs (i.e., conscientiousness, integrity, loyalty), teamwork KSAs (i.e., cooperativeness, communication skills), and KSAs particularly important for telecooperation (i.e., persistence, willingness to learn, creativity, independence, interpersonal trust, intercultural skills). The VTCI was developed as an Internet-based measure acknowledging that candidates for virtual teamwork are often highly dispersed across organizations. Moreover, online assessment tools combine numerous advantages compared to traditional paper/pencil measures (e.g., easier application and coding, higher accuracy of data collection, etc.) without losses in construct validity and acceptance (e.g., Hertel, Naumann, Konradt, & Batinic, 2002; Ployhart, Weekley, Holtz, & Kemp, 2003).

Item selection

Item selection was guided by the competency model described above and followed common practice (e.g., Aguinis, Henle, & Ostroff, 2001; for details, see Lehmann, 2003). An initial item pool was developed based on the theoretical concepts of the 11 competencies. Items were either adopted based on inspections of various German personality measures (e.g., Borkenau & Ostendorf, 1993; Fahrenberg, Hampel, & Selg, 1994; Sonntag & Schäfer-Rauser, 1993) or developed by the authors in cases where no appropriate instruments were available. The initial item-pool contained 132 self-rating items measuring the following dimensions:

- *Taskwork KSAs*, which were measured with items related to conscientiousness (19 items, e.g., "Tasks with high responsibility are important to me."), integrity (9 items, e.g., "I find it important to obey rules."), and loyalty (10 items, e.g., "I am willing to accept even unpleasant tasks to support my team.").
- *Teamwork KSAs*, which were measured with items related to cooperativeness and conflict management skills (14 items, e.g., "In

case of conflicts during my work I mediate between the parties involved.'') and communication skills (11 items, e.g., ''Others consider me as quick-witted.'').

- *Telecooperation KSAs*. Items intended to measure these were related to three main aspects: self-management, interpersonal trust, and intercultural KSAs.
- *Self-management KSAs* included items addressing persistence (13 items, e.g., ''I can motivate myself easily.''), willingness to learn (14 items, e.g., ''I am fascinated by complex issues.''), creativity (10 items, e.g., ''I enjoy developing new ideas to improve my work activities.''), and independence (12 items, e.g., ''When it comes to planning a new project, I like to take over the responsibility.'').
- *Interpersonal trust* was addressed with 10 items (e.g., ''I trust my team members.'').
- *Intercultural KSAs* were also addressed with 10 items (e.g., ''I enjoy collaborating with colleagues of other nationalities.'').

All items were answered on 5-point scales ranging from ''do not agree'' (1) to ''do agree'' (5). Moreover, in the end of the pilot version, age and gender were collected as demographic variables. One final item asked whether the participants had answered the questions honestly on a 5-point answer scale.

Procedure of the pilot study

In order to evaluate construct validities and item characteristics, a prototype version of the VTCI was pilot-tested with 169 student participants at the University of Kiel, Germany (117 females, 52 males). On average, the participants were 24 years old ($SD = 4.6$; range = 19–45 years). Since the focus of the pilot study was only on internal consistency and reliability of the measure, the prototype was administered as paper/pencil questionnaire. Construct validities of paper/pencil and Internet administrations of trait measures have been found as rather similar (e.g., Hertel et al., 2002.)

Results of the pilot study

All participants indicated that they had answered the questionnaire honestly ($n = 128$) or nearly honestly ($n = 41$). The main goal of the pilot study was to reduce the item-pool to a brief (three or four items per subscale) but still reliable set of items related to our competency model. An initial principal component analysis (Varimax rotation) of the 132 items revealed 39 components with Eigenvalues >1 and no clear cut-off according to a Scree

test. As could have been expected for an item pool that size, this initial analysis did not show a meaningful factor structure. Following common standards of item analysis, we reduced the number of items in a step-wise procedure. Items were omitted that showed extreme endorsement rates (lower than .20 or higher than .80), high crossloadings, or low intercorrelations with other items addressing the same theoretical construct. Based on this iterated revision procedure, 39 items were finally selected.

A principal component analysis of these 39 items to explore whether our item selection was meaningful revealed 11 factors with Eigenvalues >1, corresponding to a visible break point according to a Scree test. These 11 factors explained 65.3% of variance (using the same sample as in the first PCA might be in order in this initial phase of item selection). Factor loadings of most of the items were highest on the dimensions expected theoretically.[1] The endorsement rates of the selected items varied between .55 and .78, and the corrected item-total correlations mostly exceeded .35 with the exception of one item of the loyalty subscale (cf. Table 1). Reliabilities (Cronbach's alpha) of the 11 subscales were mostly satisfying given the scale length of three or four items per subscale, again with the exception of the loyalty subscale (cf. Table 1). The mean interitem correlation was .25 for the loyalty subscale.

Intercorrelations between the 11 subscales were moderate and in line with the theoretical model, revealing predominantly higher correlations between subscales within each of the superordinate categories than across. Moreover, no significant correlations occurred between the subscales and the age of the participants, all $rs < |.15|$. Gender correlated significantly with six of the subscales. Male compared to female participants showed somewhat higher scores in learning motivation ($Ms = 3.94$ vs. 3.45), $t(167) = 4.16$, $p < .001$, creativity ($Ms = 3.91$ vs. 3.47), $t(167) = 4.09$, $p < .001$, independence ($Ms = 3.85$ vs. 3.49), $t(167) = 3.35$, $p < .01$, and persistence ($Ms = 3.74$ vs. 3.49), $t(167) = 1.98$, $p = .05$, while revealing somewhat lower scores in integrity ($Ms = 3.61$ vs. 3.92), $t(167) = 2.31$, $p < .03$, and interpersonal trust ($Ms = 3.9$ vs. 3.5), $t(167) = 2.58$, $p < .02$. These gender differences are largely consistent with other results in the literature (e.g., Costa, Terracciano, & McCrae, 2001; Feingold, 1994).

DISCUSSION

Based on this pilot study with 169 student participants, an item pool of 132 items had been pretested as paper/pencil questionnaire. Following common standards of item-analysis, a 39-item set was selected to measure the 11 constructs of our conceptual model. With only three or four items per

[1]A table with these factor loadings is available on request from the first author.

TABLE 1

Number of items, range of item endorsement rates, corrected item-total correlations, scale reliabilities (alpha), and intercorrelations of the 11 subscales (39 selected items) of the pilot study ($N = 169$)

	Number	*Item endorsement rates*	*Corrected item-total correlations*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1. Loyalty	3	.65–.73	.22–.51	(.48)										
2. Integrity	4	.61–.77	.36–.45	.31**	(.65)									
3. Conscientiousness	4	.61–.71	.40–.53	.40**	.40**	(.68)								
4. Cooperativeness	4	.63–.78	.42–.59	.29**	.10	.24**	(.69)							
5. Communication skills	4	.60–.66	.45–.60	.19*	.03	.45**	.32**	(.73)						
6. Learning motivation	3	.63–.68	.43–.59	.14	−.07	.31**	.18*	.32**	(.70)					
7. Creativity	4	.55–.70	.51–.68	.16	−.05	.28**	.29**	.45**	.59**	(.76)				
8. Independence	3	.59–.73	.37–.44	.23**	.20*	.53**	.27**	.47**	.58**	.54**	(.60)			
9. Persistence	3	.62–.67	.41–.59	.23**	.22**	.46**	.23**	.34**	.32**	.26**	.57**	(.67)		
10. Interpersonal trust	3	.68–.74	.37–.48	.33**	.15	.18*	.17*	.03	−.05	.08	.04	.00	(.61)	
11. Intercultural KSAs	4	.68–.76	.48–.54	.24**	.11	.26**	.27**	.31**	.12	.30**	.21**	.14	.17*	(.73)

Alpha coefficients of subscales are displayed in the main diagonal. $^{**}p < .01$, $^{*}p < .05$ (two-sided).

subscale, the instrument can be considered as very economic. At the same time, the reliability scores—although not perfect—are promising, with most alphas above .65. The correlations between the subscales were only moderate and in line with the theoretical expectations. Moreover, the subscales seemed to be uncorrelated with age, and only slightly correlated with gender of participants. Before the 39-item version of the VTCI was applied in the main study, we carefully revised several items from subscales with low reliability scores (e.g., loyalty) in order to optimize their comprehensibility.

Main study

The objective of the main study was to validate the VTCI in a field context with virtual team members using an Internet-based version of the measure. Apart from exploration of internal validity of the measured competencies, supervisor ratings of participants' performance and motivation were collected at the individual level to enable concurrent validation of the VTCI. Thus, construct validation was guided by hypotheses on the factorial validity, the criterion-related validity, and the validity of the complete test battery. Moreover, we also collected supervisor ratings of effectiveness at the team level as an initial step towards the exploration of different competency aggregations.

Factorial validity

The underlying conceptual model of the VTCI (cf. Figure 1) consists of three general groups of competencies (taskwork KSAs, teamwork KSAs, and telecooperation KSAs) that are in turn operationalized by 11 subscales resulting from our requirements analysis. Hence, although intercorrelations are likely between subscales of the same general category, we expect that all subscales are reflected in a confirmatory factor analysis of the resulting data. Stated more formally:

H1: The VTCI is best described by 11 factorial dimensions.

Criterion-related validity of the subscales

In order to explore the criterion-related validity of the VTCI, supervisor ratings of team members' performance were collected at the individual level. Moreover, supervisor ratings of team members' motivation was measured because effective task fulfilment in virtual teams includes the mobilization of high effort, which should be similarly affected by the described competencies. According to the underlying conceptual model (cf. Figure 1), all 11

competencies should be relevant for performance and motivation in virtual teams. Thus:

H2: The scores of the 11 VTCI subscales are positively related to supervisory ratings of team members' individual (a) performance and (b) motivation.

Criterion-related validity of the test battery

Working in a virtual team is a complex task, which is reflected in the VTCI by the inclusion of a variety of different competencies. The combination of these different predictors as a test battery generally should yield a better prediction of performance criteria than any of the subscales alone. This effect is not only due to the larger variety of relevant aspects covered by a test battery but might also be a consequence of "suppressor effects", i.e., predictor variables that show no bivariate correlation with the criteria but significant correlations with other predictor variables and thus bind irrelevant variance of the other predictors (e.g., Lancaster, 1999; Tzelgov & Henik, 1991). The multiple validity coefficient of the VTCI test battery as predictor of the individual performance and motivation assessments was computed as measure of the overall concurrent validity of the VTCI.

Team-level analyses

In addition to the validation of the VTCI at the individual level, we also collected effectiveness ratings at the team-level in order to explore different compositions of the measured competencies. Several methods of team composition are possible. Consistent with earlier work on conventional teams (Barrick et al., 1998), we specifically considered for each team (a) the *mean score* of individual measures, (b) the *lowest score* (minimum), (c) the *highest score* (maximum), and (d) the *variability* of the individual scores. Due to the explorative character of this research, we only postulate general trends for all VTCI competencies instead of specific hypotheses for each aspect.

Extrapolating Hypothesis 2 (all VTCI competencies are positively correlated with team members' motivation and performance) to the team level, we can expect a similar positive correlation between the mean scores of the competencies within teams and team effectiveness, assuming that the different individual characteristics combine additively to a collective resource pool:

H3: The average of individual VTCI subscales within the teams should be positively correlated with team effectiveness ratings at the team level.

Expectations about correlations between the minimum or maximum individual score within a team and team effectiveness are based on the idea that a single team member can significantly affect the team outcome. This is usually a function of the structure of the team task (Steiner, 1972). The most capable member is particularly critical in disjunctive tasks (e.g., problem solving), whereas the lowest capable member determines team outcome in conjunctive tasks (e.g., assembly line). The task of the virtual teams in our sample (constantly observing and supporting chat rooms; see below) rather resembled a conjunctive structure. Thus, we expected positive correlations with team effectiveness for the minimum within-team scores but not for the maximum within-team scores:

H4: The minimum (but not the maximum) of individual VTCI subscales within the teams should be positively correlated with team effectiveness ratings at the team level.

Finally, for the variance of the VTCI competencies within the teams we expected generally a negative correlation with team effectiveness, assuming that high heterogeneity of extrafunctional competencies (not technical skills) is particularly difficult to handle under conditions of high virtuality and should increase misunderstandings and conflicts. Thus, high heterogeneity of the measured VTCI competencies should be detrimental for virtual teams:

H5: The within-team variance of the VTCI subscales is negatively correlated with team effectiveness ratings at the team level.

METHOD

Participants

The participants of the main study were recruited from a large Internet provider company where they worked voluntarily within virtual teams. These teams were responsible for the maintenance and supervision of Internet chat rooms. For each team, a team manager was responsible for the coordination of the work. The following general criteria of virtual teams (Hertel, Geister, & Konradt, 2005) were fulfilled by the teams: (1) The team members worked together on a common task and had to coordinate their work, (2) the team members worked at different locations that were dispersed all over Germany, and (3) the team members communicated predominantly via electronic media to coordinate their work.

Two hundred and forty-two out of five hundred and forty-eight invited team members completed an Internet-based version of the VTCI, yielding a

response rate of 44.2%.[2] Average age of participants was 31.7 years ($SD = 9.4$, range: 18 – 58). Sixty-two per cent of the participants were male, thirty-four per cent female. The average percentage of the online time spend for the team was about 52% ($SD = 25.8$). The average team size was 12 members ($SD = 5.4$). Team members belonged to the teams for between one and seventy-eight months ($M = 16.3$, $SD = 16.6$). Team members were additionally assessed by the team managers. These team managers only assessed members that they felt they knew sufficiently, leading to a larger number of missing data for this variable. Finally, team managers also rated the effectiveness of the whole team on several indicators.

Measures

Predictors and control variables. The 11 competencies of the revised version of the VTCI were used as predictors.[3] Furthermore, the following variables were measured as control variables: age, gender, time belonging to the team, and honesty of answers.

Criteria. The manager of each team rated performance and motivation of each team member on a 4-point scale ranging from 1 = "lowest 25%" to 4 = "highest 25%". Moreover, the team manager rated the effectiveness of a team on four items using percentage scales (0 – 100%). These items included the perceived quality of the teamwork results, the initiative of the team, the team efficiency (keeping terms), and the overall team effectiveness. Twenty-five out of forty-five invited team managers participated (a return rate about 56%) and assessed 242 team members. For 118 cases, both managers' assessments and team members' questionnaires were available for the validation of the VTCI.

Procedure

The procedure included an Internet-based questionnaire to be completed by each team member, and standardized questionnaires for each member and the whole team to be completed by the responsible team manager. Participants were informed via e-mail about the purpose of the study and that the data would be kept confidential. The Internet-based questionnaire was entered with an individual password. Demographic data were collected after completion of the VTCI items. The average completion time of the questionnaire was 8.3 minutes ($SD = 3.9$). In the team-level analyses, only

[2]Sixteen participants with more than 50% missing data in one of the subscales have been omitted. Other missing data have been replaced by the subscale mean.

[3]For explorative reasons, additional self-assessment items were included in the questionnaire that are not subject of this paper.

teams were included in which at least two members returned the questionnaire, resulting in a sample of 22 teams.[4]

RESULTS

Confirmatory analysis

A confirmatory factor analysis (CFA) was conducted to test the fit of the VTCI data to the underlying model. Of the original 11 subscales, only 10 were considered in the CFA because the subscale measuring intercultural KSAs showed too many missing values, presumably because most participants were German and the teams had not much experience with intercultural collaboration. Including the items of this subscale would have overly reduced the sample size of the CFA. The remaining 35 items showed moderate skewness and curtosis mostly between +1 and −1, with the average of absolute skewness values = .86. A maximum likelihood discrepancy function could be used because simulation studies have demonstrated that this estimation procedure is quite robust to non-normality (e.g., McDonald & Ho, 2002). Based on a multifaceted approach, we selected a combination of absolute (RMR, RMSEA) and relative fit indices (CFI, TLI; cf. Table 2). Among the different models, the RMR (.052) and the RMSEA (.056) of the 10-factor model came close to the desired cutoff for good fit (< .05) and indicated an acceptable fit (< .08, e.g., McDonald & Ho, 2002). The comparative fit index (CFI = .87) and the Tucker-Lewis Index (.85) of the 10-factor model just missed the conventional cutoff (> .9, e.g., McDonald & Ho, 2002). However, using an alternative scale free least-squares (SLS) discrepancy function (AMOS 5.0) that is less vulnerable to

TABLE 2
Model fit indices (maximum likelihood) for different models of the VTCI structure (intercultural KSAs excluded)

Competing model	*Chi2*	*df*	*RMR*	*RMSEA*	*TLI*	*CFI*
Independence model	3521.12**	595	.192	.143	.000	.000
One-factor model	1615.47**	569	.070	.087	.631	.653
Three-factor model	1262.18**	564	.067	.070	.763	.778
Four-factor model	1119.65**	560	.061	.065	.795	.809
Ten-factor model	907.37**	515	.052	.056	.845	.866

**$p < .001$.

[4]A more restrictive selection of teams would have reduced the sample size too much. However, the ratio of missing data were relatively high in some teams so that the results of the exploratory team-level analyses have to be taken with caution (cf. Timmerman, 2005).

departures from normal distributions of the variables revealed even a good fit of the 10-factor model, with RMR = .048, the relative fit index (RFI) = .934, and the normed fit index (NFI) = .943.

As alternative models we considered a one-factor model, a three-factor model accumulating the subscales within each of the three superordinate categories (taskwork, teamwork, and telecooperation KSAs), and a four-factor model again summarizing the subscales within the taskwork and teamwork categories but separating interpersonal trust from the other self-management KSAs (learning motivation, creativity, independence, persistence) within the telecooperation KSAs. Table 2 demonstrates that, consistent with Hypothesis 1, the 10-factor model shows the best fit of the four different models. Together, these results suggest that the expected 10-factor model provides a reasonable fit to the data.

Scale reliabilities and intercorrelations

Table 3 presents the alpha reliabilities and the intercorrelations between the 11 subscales.[5] Six of the subscales had reliabilities above .70, which can be seen as sufficient given the early stage of this research (Nunnally, 1978; see also Lance, Butts, & Michels, 2006) and a scale length of three or four items. However, five subscales had only reliabilities between .60 and .70, indicating potential limitations of this study.

Table 3 also reveals that the 11 subscales were positively and mostly only moderately intercorrelated. As the different VTCI subscales all measure aspects that contribute to persons' potential to work successfully in a virtual team, they were combined to a test battery composite. The overall reliability of the test battery (39 items) was $r_{tt} = .92$, ($r_{tt} = .91$ without the four items measuring intercultural KSAs).

Exploring the bivariate correlations with team managers' ratings of team members revealed three subscales (loyalty, cooperativeness, intercultural KSAs) that correlated significantly with both performance and motivation ratings as criteria variables (tested one-sided; cf. Table 3). Moreover, conscientiousness and integrity showed meaningful correlations with the motivation ratings, $r = .16$, $p < .05$, and $r = .15$, $p = .05$ (one-sided). Thus, although Hypothesis 2 has not been confirmed completely, the results are consistent with our expectations for at least some subscales. Moreover, the correlations between the other VTCI subscales and the two criteria variables were mostly in the expected direction, although not significant.

[5]The subscale intercultural skills is included here for explorative reasons. Alpha reliability was .79 for those participants who had answered all four items of the subscale ($N = 93$). In the following correlation analyses, missing data of this subscale were estimated by the subscale mean.

TABLE 3

Number of items, range of item endorsement rates, corrected item-total correlations, scale reliabilities (alpha) and intercorrelations of the 11 subscales of the VTCI and criteria variables in the main study ($N = 242$)

	Number of items	*Item endorsement rates*	*Corrected item-total correlations*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Loyalty	3	.75 – .88	.44 – .52	(.67)											
2. Integrity	4	.77 – .89	.44 – .59	.61**	(.73)										
3. Conscientiousness	4	.72 – .87	.34 – .49	.51**	.52**	(.65)									
4. Cooperativeness	4	.54 – .67	.48 – .60	.30**	.25**	.27**	(.72)								
5. Communication skills	4	.61 – .71	.45 – .53	.32**	.22**	.38**	.54**	(.71)							
6. Learning motivation	3	.73 – .79	.43 – .59	.32**	.32**	.47**	.44*	.48**	(.76)						
7. Creativity	4	.70 – .74	.49 – .61	.34**	.31**	.47**	.52**	.48**	.69**	(.75)					
8. Independence	3	.69 – .80	.43 – .56	.25**	.23**	.55**	.49**	.56**	.63**	.67**	(.66)				
9. Persistence	3	.74 – .79	.43 – .46	.41**	.36**	.60**	.35**	.50**	.50**	.52**	.60**	(.64)			
10. Interpersonal trust	3	.73 – .88	.39 – .44	.36**	.33**	.18**	.13*	.22**	.21**	.13*	.05	.12	(.60)		
11. Intercultural KSAs	4	.79 – .85	.53 – .65	.36**	.25**	.43**	.34**	.38**	.49**	.41**	.39**	.41**	.17*	(.79)	
12. Individual performance (manager ratings)				.30**	.04	.12	.29**	.05	−.02	.07	.12	.11	−.06	.17*	
13. Individual motivation (manager ratings)				.31**	.15*	.16*	.25**	.11	.06	.08	.09	.07	.02	.21*	.80**

**$p < .01$, *$p \leq .05$ tested two-sided for intercorrelations of the 11 VTCI subscales, and tested one-sided for intercorrelations with performance and motivation ratings (last two lines) based on Hypothesis 2. Missing data of single intercultural KSA items were estimated by the subscale mean. Due to missing data of the managers' ratings, the correlations between the first 10 VTCI subscales and managers' performance/motivation ratings were based on $N = 118$, and the correlations between intercultural KSAs and managers' performance/motivation ratings were based on $N = 101$.

Validity of the VTCI battery

In order to assess the criteria-related validity of the VTCI, multiple regression analyses were performed. A multiple regression of team members' rated performance as criteria entering all VTCI subscales as predictors revealed a significant overall effect, $F(11, 89) = 2.51$, $p < .01$.[6] The multiple correlation of the VTCI battery was substantial, $R = .49$, explaining about 24% of the variance of team members' performance ratings. Significant beta weights were observed for four subscales (loyalty, integrity, cooperativeness, communication skills; cf. Table 4). The beta weights of loyalty and cooperativeness are in line with our expectations and similar to the reported bivariate correlations with performance ratings.

Interestingly, the beta weight of loyalty, beta = .40, even exceeds the bivariate correlation score, $r = .30$. At the same time, the conceptually related subscale of integrity showed a significant correlation with loyalty, $r = .61$, but nearly zero correlation with the performance criteria, $r = .04$. Finally, the beta weight of integrity in the regression is significantly negative, beta = −.30 (cf. Table 4). Together, this result pattern suggests a suppressor

TABLE 4
Results of the regression analysis on individuals' motivation and performance based on supervisor ratings

	Individual performance			*Individual motivation*		
Variables	*B*	*Beta*	*Sign.*	*B*	*Beta*	*Sign.*
Loyalty	.65	.40	**	.48	.30	*
Integrity	−.44	−.30	*	−.17	−12	
Conscientiousness	−.03	−.02		.13	.08	
Cooperativeness	.32	.24	*	.23	.18	
Communication skills	−.37	−.27	*	−15	−.11	
Learning motivation	−.17	−.15		−.07	−.06	
Creativity	.01	.01		.00	.00	
Independence	.23	.17		.11	.08	
Persistence	.10	.07		−.06	−.05	
Interpersonal trust	.10	.07		.18	.15	
Intercultural KSAs	.12	.11		.12	.12	
Multiple R (adj. R^2)	.49	(.14)	**	.42	(.07)	†

†$p < .10$, *$p < .05$, **$p < .01$ (beta weights tested one-sided based on Hypothesis 2). $N = 101$ due to missing data.

[6]Reduced sample size because the team managers only rated those team members who they felt they knew sufficiently.

effect of the integrity subscale, binding irrelevant variance of loyalty and thus increasing the validity of loyalty as predictor. This conclusion is additionally confirmed applying the formula developed by Tzelgov and Henik (1991).[7]

A similar suppressor effect is suggested by the negative beta weight of communication skills, beta = −.27, which correlated highly, $r = .54$, with the conceptually related and significant predictor cooperativeness but about zero, $r = .05$, with the performance criteria. However, this time the beta weight of cooperativeness, beta = .24, did not exceed the bivariate correlation score with performance ratings, $r = .29$. Thus, although communication skills seemed to bind irrelevant variance of the predictor cooperativeness, controlling for this variable did not increase the validity of cooperativeness in the regression.

It should be noted that also nonsignificant predictors such as intercultural skills, independence, and persistence contribute to the multiple R. If restricted only to the four subscales with significant beta weights, the multiple R would be .42. On the other hand, supervisors' performance ratings were unrelated to age, time belonging to the team, and self-ratings of honesty in the questionnaire, all rs $< |.18|$. Only gender showed a significant correlation, $r = .20$, $p < .05$, due to the fact that female team members received slightly better performance ratings.[8]

The same regression analysis for motivation ratings just missed the conventional significance threshold, $F(11, 89) = 1.70$, $p < .09$. In this regression, only loyalty had a significant beta weight (cf. Table 4). However, the predictive validity of the test battery is still high with a multiple $R = .42$.

Team-level analyses

Finally, we computed aggregation scores of the VTCI subscales at the team level and correlated these scores with the supervisors' overall team effectiveness assessments that were based on the average of three team effectiveness ratings (quality of work, initiative of the team, overall

[7]More formally (Tzelgov & Henik, 1991), a suppressor effect exists when

$$(r_{cp} - r_{cs}\, r_{ps})/(1 - r_{ps}{}^2) - r_{cp} > 0$$

The correlation between the criterion (c) and the predictor (p) is denoted as r_{cp}, the correlation between the criterion (c) and the suppressor (s) is denoted as r_{cs}, and the correlation between the predictor (p) and the suppressor (s) is denoted as r_{ps}. For the given correlations between performance rating as criterion, loyalty as predictor, and integrity as suppressor, this equation equals .14, which is > 0.

[8]The general regression results were virtually the same when gender was entered as a first step into the regression.

effectiveness of the team; alpha = .86).[9] Four composition indicators of the VTCI subscales were considered (cf. Barrick et al., 1998): mean score within teams, minimum score within teams, maximum score within teams, and variance of the VTCI competencies within teams. Positive correlations with team effectiveness ratings at the team level were expected for mean scores (H3) and minimum scores (H4), no correlation for maximum scores (H4) and negative correlations for the variance of VTCI competencies (H5).

First, looking at the *mean* scores of the VTCI subscales within the teams, team effectiveness correlated significantly with creativity, $r = .38$, $p < .05$. However, given the rather small sample size of 22 teams and the range restriction of variability between the teams (cf. Footnote 9), nonsignificant correlation scores higher than $r = .25$ might also be considered for explorative reasons. Such correlations occurred for cooperativeness, $r = .30$, $p < .09$, learning motivation, $r = .28$, $p < .11$, and conscientiousness, $r = .28$, $p < .11$, all tested one-sided, cf. Table 5). Together, these initial results provide some tentative evidence for Hypothesis 3 because *within team mean* scores of four of the eleven VTCI subscales showed positive correlations with team effectiveness, while no negative correlation occurred.

TABLE 5
Team-level correlations of different VTCI aggregations with team effectiveness ratings by supervisors ($N = 22$)

	Team-level aggregation mode			
VTCI subscales	*Average*	*Minimum*	*Maximum*	*Variance*
Loyalty		.26		
Integrity				
Conscientiousness	.28	.33†		−.39*
Cooperativeness	.30†	.47*		−.51**
Communication skills				
Learning motivation	.28			
Creativity	.38*	.40*		−.29†
Independence		.29†		−.28
Persistence				
Interpersonal trust				
Intercultural KSAs				

†$p < .10$, *$p < .05$, **$p < .01$ (tested one-sided). Only correlation scores $> .25$ are displayed for reasons of clarity.

[9]Multilevel analyses considering the team effectiveness ratings in addition to the ratings of the individual members might have been also appropriate here. However, testing the baseline model revealed that there is not sufficient variability in the means across groups to proceed with the multilevel analysis.

Secondly, looking at the *minimum* of the VTCI scores within the teams, significant correlations with team effectiveness were observed for cooperativeness, $r = .47$, $p < .03$, and creativity, $r = .40$, $p < .04$. Further positive correlations that missed the conventional significance threshold were observed for conscientiousness, $r = .33$, $p < .07$, independence, $r = .29$, $p < .10$, and loyalty, $r = .26$, $p < .12$ (all tested one-sided). These results provide tentative evidence for Hypothesis 4. Moreover, none of the within team minimum VTCI scores showed negative correlations with team effectiveness. As expected, no substantial correlations occurred for *within team maximum* VTCI scores, all $rs < |.20|$.

Finally, exploring the *variance* of the VTCI predictors within teams as a measure of heterogeneity, significant negative correlations with team effectiveness were observed for cooperativeness, $r = -.51$, $p < .01$, and conscientiousness, $r = -.39$, $p < .04$. Similar to research with conventional teams (Barrick et al., 1998), heterogeneity in cooperativeness (teamwork aspects) and conscientiousness (taskwork aspects) seem to be detrimental also for virtual teams. Further negative correlations, although not significant, occurred for creativity, $r = -.29$, $p < .10$, and independence, $r = -.28$, $p < .11$ (all tested one-sided) while no positive correlations were observed (cf. Table 5). Together, these initial results provide tentative evidence for Hypothesis 5.

GENERAL DISCUSSION

The purpose of this study was to develop and validate an efficient measure for the selection and placement of members in virtual teams. A conceptual competency model was developed, distinguishing taskwork KSAs, teamwork KSAs, and telecooperation KSAs as three major groups of selection criteria that were further subdivided into 11 competencies. In order to measure these competencies, the Virtual Team Competency Inventory (VTCI) was developed out of a larger item pool and pretested in a pilot study with 169 student participants. The resulting 39-item measure of the VTCI contained three to four items for each of the 11 subscales and could be administered on the Internet. Requiring only about 10 minutes completion time, the VTCI can be considered as efficient.

Consistent with Hypothesis 1, the data of the main validation study showed satisfying construct validity of the measure. A confirmatory factor analysis revealed the underlying measurement model for 10 of the 11 competencies. The intercultural KSAs subscale had to be excluded in the CFA due to a high amount of missing data. However, this subscale showed satisfying reliability for those participants who had completed all four items of the subscale. Five of the other subscales showed also sufficient reliability scores given the early stage of this research (Lance et al., 2006). The

remaining five subscales, most of them having only three items, showed reliabilities between .60 and .70 and need to be improved in the future. Finally, the overall reliability of the VTCI measure was satisfying, $r_{tt} = .92$.

In order to assess the predictive validity of the VTCI at the individual data level, the single competencies and the overall VTCI composite were compared with team managers' ratings of the performance and motivation of the virtual team members. Partly consistent with Hypothesis 2, most of the correlations between individual competencies and team members' performance were in the expected positive direction, although only few of these correlations were significant. However, when the assessed performance of the virtual team members was regressed based on all 11 VTCI subscales, a multiple R of .49 documented good convergent validity, indicating that the VTCI battery explains about 24% variance of the rated performance. (Similar but slightly lower and nonsignificant results occurred for the assessed motivation of team members.) Please note that this is a conservative interpretation because reliability corrections of the criteria measure are not taken into account. Moreover, the validity of the VTCI is probably underestimated in this study due to range restriction effects, given that the participants had voluntarily chosen to work on the virtual teams. Thus, when employees are allocated into virtual teams by supervisors and the reliability of the criteria measure is improved, the predictive validity of the VTCI might be even higher.

In the regression of team members' rated performance, the main predictors were loyalty and cooperativeness, confirming our argument that virtual teams are not completely different from conventional teams but require similar competencies. Interestingly, the predictive validity of loyalty was even increased in the regression of team members' rated performance due to a suppressor effect of the integrity subscale. A content analysis of the four integrity items selected revealed a strong focus on rules, measuring how strongly participants valued rules and felt committed to rules. Given that virtual teamwork entails a (new) work environment that often requires flexibility and ad hoc problem solving, team members who stick too strongly to rules and fixed structures might be indeed not well suited compared to those who are more flexible. The observed suppressor effect suggest that more general aspects of team-related reliability, such as loyalty, are positive for teams with high levels of virtuality, while aspects of reliability in the sense of rigid rule adherence are rather detrimental. Of course, this result has to be replicated in future research.

A similar pattern occurred within the teamwork KSAs, i.e., for cooperativeness and communication skills. While cooperativeness showed significant positive beta weights in the regression of team members' rated performance, communication skills revealed a negative beta weight even though the bivariate correlation with performance ratings was about zero. Analysing the items measuring communication skills revealed a focus on

skills particularly relevant for face-to-face communication (e.g., being quick-witted), and the observed results suggest that these skills are not that important for virtual teams. Indeed, controlling for this subscale in the overall regression did not increase to predictive validity of cooperativeness. Future research might explore additional communication items that also consider electronic media use (e-mail, telephone, video-conferencing, etc.) that often require different skills than face-to-face communication (Hertel, Schroer, Batinic, Konradt, & Naumann, 2005).

The contributions of the considered telecooperation KSAs for predicting performance and motivation of virtual team members at the individual level were minor at best, even though they were mostly in the expected direction. However, these results should be interpreted carefully given the pioneering character of this research and the limitations discussed below. Moreover, consistent with Hypotheses 3, 4, and 5, initial correlations between some telecooperation KSAs (particularly those related to self-management) and team effectiveness were observed. Both average and minimum amounts of these competencies correlated positively with virtual team effectiveness. These results provide tentative evidence for the assumed importance of telecooperation KSAs at least at the team level. The team effectiveness ratings might be more valid than the ratings of individual team members because the main focus of the team managers was on the team, and no periodical assessments of the team members were applied because they worked voluntarily. Finally, the negative team-level correlation between team effectiveness and heterogeneity scores of two of the telecooperation KSAs (creativity and independence), as well as heterogeneity of cooperativeness and conscientiousness, illustrate that the distribution of competencies within virtual teams can be important. Consistent with Hypothesis 5, these results suggest that heterogeneity of extrafunctional competencies might be rather detrimental for virtual teams.

Before closing, several noteworthy limitations of this study should be pointed out, along with future research directions. First, although the sample size of our study is higher than in many other empirical papers on virtual teams (see, for reviews, Axtell et al., 2004; Hertel, Geister, & Konradt, 2005), clearly more teams and more complete data sets would be desirable. In particular, the relatively low number of available team data sets restricted the power of the team-level analyses. Future research should replicate the current findings with more virtual teams and varying forms of virtual teamwork (see Bell & Kozlowski, 2002; Hertel, Geister, & Konradt, 2005, for taxonomies). In particular, replications with paid workers, as compared to the voluntary workers in our study, are desirable.[10]

[10]The complete VTCI will be provided by the first author for further replication and validation studies on request.

Secondly, our initial study focused only on teams with relatively high levels of virtuality. It would be interesting to investigate potential differences in the competency profiles with varying degrees of virtuality. For instance, the impact of the telecooperation KSAs is considered as positively related with the degree of team virtuality (Kirkman & Mathieu, 2005). Thirdly, as already mentioned, the accuracy of the criteria might be improved, particularly for the individual-level measures. In the present study, the team managers often had more information about the team than about each individual member. Moreover, the managers had neither been trained nor were used to applying individual assessments in the past due to the voluntary nature of the work. Future studies should collect more accurate performance ratings at the individual level and perhaps include also peer and self ratings. Also, satisfaction ratings of the team members along with group-level data on cohesion, team climate, etc. would be interesting. Finally, although the importance of some of the VTCI competencies has been demonstrated, the importance of others—such as interpersonal trust—could not be confirmed in this study. Of course, this might be due to manifold reasons (lack of variance in the current sample, reliability problems of the subscales, etc.) and should be further explored before a competency is entirely dropped from the inventory. In the case of trust, however, empirical evidence from other work suggests that its impact might be overestimated for virtual cooperation (e.g., Aubert & Kelsey, 2003; Hertel, Konradt, & Orlikowski, 2004; Hertel, Niedner, & Herrmann, 2003).

This article documents the development and initial empirical validation of an economic Internet-based measure for the selection of virtual team members. Although the resulting measure can be further improved, the current data on construct validity, concurrent validity, and economy of application are promising. Together with our theoretical competency model, we hope this research will initiate further research activities in this growing field.

REFERENCES

Akademie fuer Fuehrungskraefte der Wirtschaft (AFW). (2002). *Mythos Team auf dem Prüfstand: Teamarbeit in deutschen Unternehmen* [The myth of team being tested: Teamwork in German companies]. Bad Harzburg, Germany: Author. Retrieved May 2005, from http://www.die-akademie.de/

Aguinis, H., Henle, C. A., & Ostroff, C. (2001). Measurement in work and organizational psychology. In N. Anderson, D. S. Ones, H. K. Sinangil, & C. Viswesvaran (Eds.), *Handbook of industrial, work and organizational psychology* (Vol. 1, pp. 27–50). London: Sage.

Allen, N. J., & Hecht, T. D. (2004). The "romance of teams": Toward an understanding of its psychological underpinnings and implications. *Journal of Occupational and Organizational Psychology*, *77*, 439–461.

Aubert, B. A., & Kelsey, B. L. (2003). Further understanding of trust and performance in virtual teams. *Small Group Research*, *34*, 575–618.

Axtell, C. M., Fleck, S. J., & Turner, N. (2004). Virtual teams: Collaborating across distance. In C. L. Cooper & I. T. Robertson (Eds.), *International review of industrial and organizational psychology* (Vol. 19, pp. 205–248). Chichester, UK: Wiley.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*, 191–215.

Barrick, M. R., Stewart, G. L., Neubert, M. J., & Mount, M. K. (1998). Relating member ability and personality to work-team processes and team effectiveness. *Journal of Applied Psychology*, *83*, 377–391.

Barry, B., & Stewart, G. L. (1997). Composition, process, and performance in self-managed groups: The role of personality. *Journal of Applied Psychology*, *82*, 62–78.

Bell, B. S., & Kozlowski, S. W. J. (2002). A typology of virtual teams: Implications for effective leadership. *Group and Organization Management*, *27*, 14–49.

Blackburn, R., Furst, S., & Rosen, B. (2003). Building a winning virtual team: KSAs, selection, training, and evaluation. In C. B. Gibson & S. G. Cohen (Eds.), *Virtual teams that work: Creating conditions for virtual team effectiveness* (pp. 95–120). San Francisco: Jossey-Bass.

Borkenau, P., & Ostendorf, F. (1993). *NEO-Fünf-Faktoren Inventar (NEO-FFI) nach Costa und McCrae* [NEO Five Factor Inventory following Costa and McCrae]. Göttingen, Germany: Hogrefe.

Costa, P. T., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology*, *81*, 322–331.

Duarte, D. L., & Snyder, N. T. (2001). *Mastering virtual teams*. San Francisco: Jossey-Bass.

Ellingson, J. E., & Wiethoff, C. (2002). From traditional to virtual: Staffing the organization of the future today. In R. L. Henemann & D. B. Greenberger (Eds.), *Human resource management in virtual organizations* (pp. 141–177). Greenwich, CT: Information Age Publishing.

Fahrenberg, J., Hampel, R., & Selg, H. (1994). *Das Freiburger Persönlichkeitsinventar FPI. Revidierte Fassung* [The Freiburg Personality Inventory FPI–Revised version]. Göttingen, Germany: Hogrefe.

Feingold, A. (1994). Gender differences in personality: A meta-analysis. *Psychological Bulletin*, *116*, 429–456.

Finholt, T. A. (2002). Collaboratories. *Annual Review of Information Science and Technology*, *36*, 73–107.

Gibson, C. B., & Cohen, S. G. (Eds.). (2003). *Virtual teams that work: Creating conditions for virtual team effectiveness*. San Francisco: Jossey-Bass.

Harvey, M., Novicevic, M. M., & Garrison, G. (2004). Challenges to staffing global virtual teams. *Human Resource Management Review*, *14*, 275–294.

Haywood, M. (1998). *Managing virtual teams: Practical techniques for high-technology project managers*. Boston: Artech House.

Hertel, G., Deter, C., & Konradt, U. (2003). Motivation gains in computer-supported teams. *Journal of Applied Social Psychology*, *33*, 2080–2105.

Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review*, *15*, 69–95.

Hertel, G., Konradt, U., & Orlikowski, B. (2004). Managing distance by interdependence: Goal setting, task interdependence, and team-based rewards in virtual teams. *European Journal of Work and Organizational Psychology*, *13*, 1–28.

Hertel, G., Naumann, S., Konradt, U., & Batinic, B. (2002). Person assessment via Internet: Comparing online and paper-and-pencil questionnaires. In B. Batinic, U. Reips, & M. Bosnjak (Eds.), *Online social sciences* (pp. 115–133). Berlin, Germany: Hogrefe.

Hertel, G., Niedner, S., & Herrmann, S. (2003). Motivation of software developers in Open Source projects: An Internet-based survey of contributors to the Linux kernel. *Research Policy*, *32*, 1159–1177.

Hertel, G., Schroer, J., Batinic, B., Konradt, U., & Naumann, S. (2005). Kommunizieren schüchterne Menschen lieber per E-mail? Einflüsse der Persönlichkeit auf die Präferenz von Kommunikationsmedien [Do shy persons rather send an e-mail? Personality effects on the preference of communication media]. In K.-H. Renner, A. Schütz, & F. Machilek (Eds.), *Internet und Persönlichkeit* (pp. 134–147). Göttingen, Germany: Hogrefe.

Hinds, P., & Kiesler, S. (Eds.). (2002). *Distributed work*. Cambridge, MA: MIT Press.

Hofner Saphiere, D. M. (1996). Productive behaviors of global business teams. *International Journal of Intercultural Relations*, *20*, 227–259.

James, K., & Cropanzano, R. (1994). Dispositional group loyalty and individual action for the benefit of an ingroup: Experimental and correlational evidence. *Organizational Behavior and Human Decision Processes*, *60*, 179–205.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and trust in global virtual teams. *Organization Science*, *10*, 791–815.

Kirkman, B. L., & Mathieu, J. E. (2005). The dimensions and antecedents of team virtuality. *Journal of Management*, *31*, 700–718.

Klein, K. J., & Kozlowski, S. W. J. (2000). From micro to meso: Critical steps in conceptualizing and conducting multilevel research. *Organizational Research Methods*, *3*, 211–236.

Konradt, U. & Hertel, G. (2002). *Management virtueller Teams* [Managing virtual teams.]. Weinheim: Beltz.

Konradt, U., Schmook, R., Wilm, A., & Hertel, G. (2000). Health circles for teleworkers: Selective results on stress, strain, and coping styles. *Health Education Research*, *15*, 327–338.

Kozlowski, S. W. J., & Bell, B. S. (2003). Work groups and teams in organizations. In W. C. Borman, D. R. Ilgen, & R. J. Klimoski (Eds.), *Handbook of psychology: Vol. 12. Industrial and organizational psychology* (pp. 333–376). Hoboken, NJ: John Wiley & Sons.

Lancaster, B. P. (1999). Defining and interpreting suppressor effects: Advantages and limitations. In B. Thompson (Ed.), *Advances in social science methodology* (pp. 139–148). Stanford, CA: JAI Press.

Lance, C. E., Butts, M. M., & Michels, L. C. (2006). The sources of four commonly reported cutoff criteria. What did they really say. *Organizational Research Methods*, *9*, 202–220.

Lehmann, K. (2003). *Auswahl von Mitgliedern virtueller Teams* [Selection of members of virtual teams]. Wiesbaden, Germany: Deutscher Universitäts-Verlag.

Lipnack, J., & Stamps, J. (1997). *Virtual teams*. New York: Wiley.

Marshall, C., & Novick, D. (1995). Conversational effectiveness and multi-media communications. *Information Technology and People*, *8*, 54–79.

Maruping, L. M., & Agarwal, R. (2004). Managing team interpersonal processes through technology: A task-technology fit perspective. *Journal of Applied Psychology*, *89*, 975–990.

McDonald, R. P., & Ho, M.-H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, *7*, 64–82.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

O'Leary, M., & Cummings, J. N. (2002). *The spatial, temporal, and configurational characteristics of geographic dispersion in work teams* (Working Paper No. 148, pp. 1–31). Center for eBusiness@MIT. Retrieved May 2005, from http://ebusiness.mit.edu/Research/

Ployhart, R. E., Weekley, J. A., Holtz, B. C., & Kemp, C. (2003). Web-based and paper-and-pencil testing of applicants in a proctored setting: Are personality, biodata, and situational judgment tests comparable? *Personnel Psychology*, *56*, 733–752.

Roe, R. A. (2002). What makes a competent psychologist? *The European Psychologist*, *7*, 192–203.

Schmidt, F. L., & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin*, *124*, 262–274.

Sonntag, K., & Schäfer-Rauser, U. (1993). Selbsteinschätzung beruflicher Kompetenzen bei der Evaluation von Bildungsmaßnahmen [Self-assessment of occupational competencies during the evaluation of training interventions]. *Zeitschrift für Arbeits- und Organisationspsychologie*, *37*, 163–171.

Staples, D. S., Hulland, J. S., & Higgins, C. A. (1999). A self-efficacy theory explanation for the management of remote workers in virtual organizations. *Organization Science*, *10*, 758–776.

Steiner, I. D. (1972). *Group process and productivity*. New York: Academic Press.

Stevens, M. J., & Campion, M. A. (1994). The knowledge, skill, and ability requirements for teamwork: Implications for human resource management. *Journal of Management*, *20*, 503–530.

Stevens, M. J., & Campion, M. A. (1999). Staffing work teams: Development and validation of a selection test for teamwork settings. *Journal of Management*, *25*, 207–228.

Timmerman, T. A. (2005). Missing persons in the study of groups. *Journal of Organizational Behavior*, *26*, 21–36.

Tzelgov, J., & Henik, A. (1991). Suppression situations in psychological research: Definitions, implications, and applications. *Psychological Bulletin*, *109*, 524–536.

Warkentin, M., & Beranek, P. M. (1999). Training to improve virtual team communication. *Info Systems Journal*, *9*, 271–289.

Warkentin, M. E., Sayeed, L., & Hightower, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of a web-based conference system. *Decision Sciences*, *28*, 975–996.

Weaver, J. L., Bowers, C. A., Salas, E., & Cannon-Bowers, J. A. (1997). Motivation in teams. *Advances in Interdisciplinary Studies of Work Teams*, *4*, 167–191.

West, M. A. (2001). The human team: Basic motivations and innovations. In N. Anderson, D. S. Ones, H. K. Sinangil, & C. Viswesvaran (Eds.), *Handbook of industrial, work and organizational psychology* (Vol. 2, pp. 270–288). London: Sage.

Manuscript received July 2005
Revised manuscript received July 2006
First published online 28 August 2006