TOWARD AN OPERATIONALIZATION OF EFFECTIVE USE

Completed Research Paper

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Abstract

A major body of work in the IS discipline, studies of individuals' technology acceptance and adoption are increasingly criticized for their shallow conceptualization of use behaviors, especially after adoption. To overcome such critique, Burton-Jones and Grange (2013) have recently proposed the construct of effective use (EU). While promising in its more refined perspective on what enables users to use an information system effectively (i.e., transparent interaction, representational fidelity, and informed action), much of this debate has been purely conceptual to date. We pick up EU's extant conceptualization and propose a measurement model for it. Through engagement with field and panel data, we are able to validate our proposed measurements and, for the first time, are able to take a look at the exact empirical relationship between the sub-constructs that constitute EU. This helps to advance the extant EU conceptualization and enables future empirical work on its validation and extension.

Keywords: Effective Use, Enterprise System, Measurement, Operationalization.

1 Introduction

A large amount of the costs that accrue in most information systems (IS) implementation projects are attributable to the post-implementation stage (Erlikh 2000). Organizations aim to make these costs worthwhile by generating the maximum value over the course of the overall use phase (Venkatesh, Brown, Maruping, and Bala, 2008). In this, employees' ability to make sense of the meaning of presented data can be reduced by an ill-designed feature. Confusing menus or screens in an enterprise system can be a prominent example for impediments to its effective use (EU). As a result, users cannot put sufficient focus and emphasis on the implications of the data (lack of effectiveness) and they might be forced to spend additional time searching for complete data to assemble a complete view (lack of efficiency) (Burton-Jones and Grange, 2013). The following example from practice, observed in our preliminary case study, illustrates this issue: In our case organization, a global bank with roots in central Europe that performed a multiyear enterprise system implementation program, we observed that users who worked with an old Loan Management System (LMS) often did not have an integrated view on the individual customer, when processing a respective loan. Instead, they had to access information about the particular customer in several systems. This process was error prone and not as efficient as an integrated view, which allows them to take informed action straight away. However, faster actual processing and better interfaces enable clerks to process loan-related request more accurately, reducing the risk of potentially costly errors.

EU is the prerequisite for realizing many benefits in terms of increasing organizational effectiveness related to the implementation of a new enterprise system (Burton-Jones and Grange, 2013; Orlikowski, 2000). Surprisingly, when we look at the literature, we find that empirical studies on effective use are scarce. Most studies of use draw on models of IT acceptance and use - e.g., TAM (Davis, 1989); Information System Success Model (DeLone and McLean, 1992, 2003), TTF (Goodhue and Thompson, 1995), or UTAUT (Venkatesh, Morris, Davis, and Davis, 2003) – which have been criticized for treating users' responses when they work with a system as a dichotomous black box (Barki et al. 2007; Elie-Dit-Cosaque and Straub 2011). While EU helps to advance IS research's theoretical arsenal in this regard, the concept is not yet operationalized. However, operationalization and resultant measurement is a crucial prerequisite to test, refine, and advance theories on effective use (Mueller and Urbach, 2017). We therefore suggest that there is a need to operationalize the concept of EU. Specifically, we aim to analyze the relationship of the different components of EU, which are transparent interaction (TI), representational fidelity (RF), and informed action (IA) (Burton-Jones and Grange, 2013). We developed specific measures for the constructs of TI, RF, and IA. This enables us to seek an answer for the following research question: *What is the exact relationship of transparent interaction, representational fidelity, and informed action as sub-constructs of effective use?*

We expect that our research contributes to a better management of enterprise system implementations by offering a stable measure for success in terms of EU in the post-adoption phase. Section two in this paper introduces our theoretical foundations, which are subsequently used for the development of our hypotheses of the concept of EU. We then present our research design, covering the steps taken to develop the items and to collect and analyze the data in two different contexts. Subsequently, we present our results for the two datasets in detail. We conclude our paper with an assessment of the contributions, discussing theoretical implications, limitations, implications for practitioners, as well as outlining avenues for future research.

2 Theoretical Foundation

It has long been recognized that simple IS use in itself is not sufficient for significant productivity gains in the post adoption phase (Zmud and Apple, 1992). Continuing the work of early studies that highlighted the need to shift focus beyond adoption (Barki et al., 2007; Gallivan, 2001; Jasperson et al., 2005), IS research has therefore been called upon to increasingly focus on developing richer concepts of 'use' (Burton-Jones and Straub, 2006; Eli-Dit-Cosaque and Straub, 2011). While a number of conceptualizations has recently been proposed to help advance IS research in this regard – for instance, innovative use (Li et al., 2013), extended system use (Liang et al, 2015), or enhanced use (Bagayogo et al., 2014). Among these recent advances in use conceptualization, one particular approach is to better understand if users are using a technology *effectively*, that is, "using a system in a way that helps [to] attain the goals for using the system" (Burton-Jones and Grange 2013, p. 633). This definition of EU is an adaptation of the definition for system use by Burton-Jones and Straub (2006) in that a system, a user, and a goal-directed task are the basic conceptual constituents of system use. The focus of this expression was shifted towards the use of a system to attain a relevant goal, which introduced the distinction between traditional, plain system use and effective use as well as between effective use and the other, rivalry concepts mentioned earlier.

Moreover, effective use builds upon representation theory following ontological considerations of Wand and Weber (1995) and Weber (1997). Representation theory allows to encompass all kinds of IS with different purposes, which can even be different between individual users (Burton-Jones and Grange, 2013; Orlikowski, 1991). However, when applying representation theory to IS, some assumptions about the nature and the purpose of IS have been made in previous research. These should be reiterated for the purpose of our operationalization. It is implicit in representation theory that all kinds of IS are used for the purpose of understanding the state of real-world systems which are relevant to users (Burton-Jones and Grange, 2013; Ron Weber, 2003). For instance, in a business intelligence and analytics (BI&A) system this would be the state of the business, which is represented to a user in a controlling department. More specifically, the data in the system could concern the financial situation of the firm and thereby enable the user in an accounting department to take action (e.g. manage liquidity of the firm accordingly). Thus, the representations in this BI&A-system enable the user to take action in the real world based on the representations of the real world, which are relevant for the user. This concept can be applied to virtually all IS (Burton-Jones and Grange, 2013) and has been used to conceptualize enterprise systems in general (Strong and Volkoff, 2010).

Burton-Jones and Grange (2013) define effective use as an aggregate construct formed by three dimensions: Transparent Interaction (TI), Representational Fidelity (RF), and Informed Action (IA). Following Burton-Jones and Grange (2013), these three sub-constructs are defined as follows: To obtain benefits from an IS – that is, achieve work goals such as successfully completing a task – a user must first be able to access the representations through the system's surface and physical structures. Following these ideas, TI is defined as "[…] the extent to which a user is accessing the system's representations unimpeded by the system's surface and physical structures [while interacting with the system]" (p. 633). RF is described in terms of what users obtain from the system when using it, that is, fidelity that users' actions such as entering, manipulating, retrieving, or viewing representations are processed by the system appropriately and that the system and the tokens that populate the system, in turn, faithfully reflect the domain the system represents. Thus, RF is defined as "[…] the extent to which a user is obtaining representations that faithfully reflect the domain that the system represents [while interacting with the system]" (p. 633). The main purpose of using a system (utilitarian use) in an organizational context is to achieve an organizational goal such as completing a task. For that purpose, users interact with a system and leverage representations (enter, viewing, retrieving, etc.) of the system to perform actions. The more the user is able to act upon faithful representations, the more informed will her/his actions be. Ill-informed actions based on unfaithful representations lead to additional effort for correcting errors or bad decisions. Ergo, IA is defined as "the extent to which a user acts on faithful representations that he or she obtains from the system to improve his or her state in the domain" (p. 633).

Burton-Jones and Grange (2013) have argued that the sub-constructs TI, RF, and IA are hierarchically related to one another with their aggregate constituting EU. TI helps to increase RF, which in turn can lead to IA (Burton-Jones and Grange, 2013). Burton-Jones and Grange (2013) propose that the overall level of EU of an individual using a system is defined by the aggregate levels of TI, RF, and IA. In effect, EU is defined as an aggregated construct (Burton-Jones and Grange, 2013; Law, Wong, and Mobley, 1998) and can be described as the desired state that users try to achieve once they are confronted with a new technology. The hierarchical conceptualization of the relationships of the sub-constructs of EU by Burton-Jones and Grange (2013) implies that RF mediates the relationship of TI and IA. This also implies a positive effect of a higher level of TI on RF and in turn that there is a smaller direct effect of TI on IA. To our knowledge, there has been no attempt in previous research to assess the nature of these described relationships empirically. Hence, we operationalize EU and the described sub-constructs of TI, RF and IA. We think that it is of critical importance to better understand the nature of EU and measure it to obtain the full benefits of system use for individuals as well as organizations. Examples for the potential benefits of EU are the following: Users who make few errors in their work are likely to reach an improved state in their business domain. The type of performance improvements that can be expected are likely to be the reduction of errors, faster work, and increased revenues for the firm overall (Beaudry and Pinsonneault, 2005; Goodhue and Thompson, 1995; Pentland, 1989; Vessey and Galletta, 1991).

3 Hypotheses

Burton-Jones and Grange (2013) "are extending representation theory beyond its traditional use" (p. 638). Initially, only the internal view of representation theory was studied (Wand and Weber, 1990, 1995; Ron Weber, 1987). This decision was originally taken because they were only concerned with studying an IS as an object without a link to the organization in which it is implemented (Wand and Weber, 1995; Burton-Jones and Grange, 2013). Burton-Jones and Grange (2013) extended that view by applying representation theory to the external view of an IS. This includes the study of surface and physical structures of an IS and the difference between people's perception and objective reality. Moreover, they noted that their extension of representational theory is compatible with the theory of the studied artifacts, such as the IS. The theory of affordances (Gibson, 1977) was cited as the most prominent theory of artifacts. It has been suggested that representation theory and the theory of affordances can be integrated (Burton-Jones and Grange, 2013). An affordance can be defined as what an artifact offers someone (Hartson, 2003). Hartson (2003) identified four different types of affordances. First, *sensory* affordances are those that allow the user to sense, see of feel. Second, *physical* are those affordances which enable users to do something physically. Third, *cognitive* are those, which make it possible that a user thinks or knows something. Fourth, *functional* are those, which enable a user to accomplish a goal. Affordances can be nested with each other because an individual needs to be able to sense and physically interact with a system to make use of an artifact's cognitive and functional affordances (Hartson 2003). Burton-Jones and Grange (2013) suggested that this concept also applies to IS. If a user wants to obtain a representation from an information system she needs to have access to them through a IS's sensory surface and physical structure (Burton-Jones and Grange, 2013). Furthermore, Burton-Jones and Grange (2013) explain it is assumed, based on the link between affordance and representation theory, that users aim to obtain representations of the real world from an IS to cognitively understand the domain and thereupon function in it. Users often conduct an action based on the information that they obtain. This is achieved in the best way if the representations that they obtain from the IS are *faithful* (Dennis, 1996). Thus, users need to have a way of dealing with the systems that provide information and have trust in the representation of the real world that the systems present. We suggest that TI, as the unimpeded access to the representations in a system, enables faithful representations via improved access to representations (cf. Burton-Jones and Grange, 2013). For instance, if accountants can understand the output options of an IS very clearly, they have greater trust in the output. Hence, we derived the following hypothesis (see also Figure 1).

H_1: Transparent interaction has a positive effect on the representational fidelity of an IS.

Second, we will assess whether RF has a positive effect on IA. As aforementioned, a user that is becoming acquainted with a system is likely to focus on the representations of the system. This involves dealing with the surface structure and physical structure, and also a system's deep structures and the tokens that populate this structure (Burton-Jones and Grange, 2013). A focus on the deep structure and the tokens is also beneficial when someone studies the fidelity of learning to use an IS. Burton-Jones and Grange (2013) stated initially that RF is a necessary, but not a sufficient condition for IA. However, when RF would be coupled with the appropriate knowledge to take advantage of the available data, then it can be expected that individuals take IAs. On the other hand, if not enough knowledge about the meaning of the representations is available, individuals will tend to take actions, which seem to be ill-informed (Burton-Jones and Grange, 2013). For example, if accountants clearly understand and trust the accuracy of a report, they can derive a more detailed picture of an organization. Thus, we derive the following hypothesis (see also Figure 1).

H_2: Representational fidelity has a positive effect on an end-user's ability to execute informed action.

Third, one could argue, that a good access to a system's representations would enable IA. However, the unimpeded access to representations can only facilitate IA if those representations faithfully reflect the represented domain to begin with. This means that TI is a necessary condition and RF is a sufficient condition for IA. For instance, accountants are not able to produce a required report if the IS does not provide trustworthy data to them and even more so, if they do not have unimpeded access to it. On the contrary, if the system provides trustworthy representations, TI is the cornerstone for it. Based on the aforementioned insights, we derived the following hypothesis:

H_3: Representational fidelity fully mediates the relationship between transparent interaction and informed action.

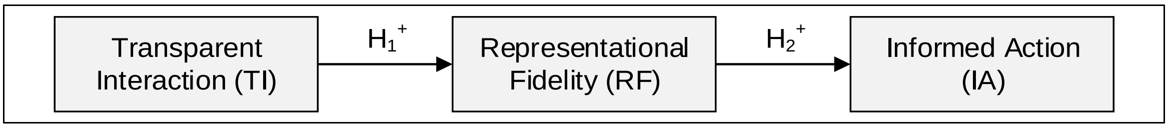


Figure 1. Research Model (based on Burton-Jones and Grange, 2013)

4 Research Methodology

For the conceptualization and operationalization of effective use (EU) we followed the approach as described by Fowler (2014) and MacKenzie et al. (2011). This approach can be roughly sub-divided into two steps. First, a set of items is developed that fits EU's sub-constructs best. Having a reasonable set, the items need to be validated in a second step. To support our conceptualization, we selected a case company that performs an enterprise system implementation project and collected data with a panel provider.

4.1 Study context

In a first wave, we collected data at BANK, a global bank with roots in central Europe that performed a multiyear enterprise system implementation program. The implementation program dealt with the replacement of the custom-built core-banking system and surrounding systems in front and middle offices with a standard software solution. The implementation followed a phased approach where the system was rolled out in several releases. At the center of our initial investigation was BANK's credit service unit (for reasons of simplicity we will refer to BANK when talking about BANK's credit service unit in the following). Here, a new Loan Management System (LMS) was implemented. LMS is a solution specific to the banking industry. It is provided by one of the world's leading software vendors and it is an industry-specific, customizable standard software package that integrates information and business processes (e.g., across various units within BANK's credit service unit and branch employees) and its implementation comes with considerable scope, complexity, and risks (Devadoss and Pan, 2007; Markus and Tanis, 2000). Service employees were faced with the implementation of the standard software LMS as part of the replacement of the whole core-banking system. The old system used to manage loans had been in place for over thirty years and had to be replaced due to technical and regulatory requirements. Early in 2013, project activities for the LMS implementation at BANK started with requirements analysis and definition followed by configuration and implementation activities and testing until November. From September onwards, change management activities (mainly trainings) were performed in BANK until December 2013. Trainings were done for all employees, starting with a one-day basic training. This was followed by self-trainings with a training-system and predefined training cases until December 2013. Our study was executed in this context. Prior to conducting the survey, we leveraged our presence in the field to also support the development of the instrument. Developing and pre-testing the instrument was partially done in situ, that is, with actual BANK employees to ensure the fit of the instrument. Due to our presence in the field we were able to collect qualitative data where and whenever possible. Together with the quantitative results, we used the insights from this qualitative inquiry to triangulate and explain our findings (Venkatesh, Brown, and Bala, 2013).

4.2 Item development

Based on thorough literature work and the conceptualization of the constructs of the model, we developed a pool of new questionnaire items (i.e., questions to capture the concepts in a survey) (MacKenzie et al., 2011) for transparent interaction (TI), representational fidelity (RF), and informed action (IA). Here, we used hints from literature and from our case company that we collected in a previous qualitative study (Lauterbach et al., 2014) to examine keywords that could be used to develop the items. Then, we discussed the questions with several researchers and with potential respondents at BANK to ensure face validity. Based on the results obtained in these discussions we revised or deleted questions that were too complex or not comprehensible (Hoehle and Venkatesh, 2015; MacKenzie et al., 2011). As a next step, we started to ensure content validity by using a card sorting technique (e.g. Davis 1989; Moore et al. 1991) for assessing the coverage of the domain of the constructs. Here, we specifically followed the approach suggested by Anderson and Gerbing (1991). The approach suggests providing skilled raters with matrixes that show the concepts as one dimension and the respective questions as another dimension. The rater is then asked to assign the questions to the respective concept. Along with the rating matrixes, we also provided further explanations through definitions of the concepts.

From the ratings, we calculated both the Proportion of Substantive Agreement (PSA) and the Coefficient of Substantive Validity (CSV) (Anderson and Gerbing, 1991). The minimal cut-off value for PSA is 0.60, which suggests that more than 60% of all raters have assigned the question to the correct concept (Anderson and Gerbing, 1991). The cut-off value for CSV is 0.5 (Anderson and Gerbing, 1991). In this step, we drew on students of an enterprise systems master course. MacKenzie et al. (2011) suggest a selection of respondents and state that raters should have sufficient intellectual capacities to perform the card sorting exercise. We exercised this step of our instrument development in two waves out of a sample of 108 students with a total set of 30 newly developed questions for the three constructs of our model. In a first wave, 55 students performed the card sorting exercise. A second wave consisted of 53 responses. After the first wave, we refined the wording of concept definitions and questions and added several new questions. Based on the second wave we had seven items that fulfilled the 0.6 cut-off criterion for PSA as well as the 0.5 cut-off for CSV; these items were retained. Another 12 items fulfilled the 0.6 cut-off criterion for PSA. We analyzed the remaining eleven 11 items critically and discussed the results. As not all of the remaining items fulfilled the quality criteria of PSA and CSV, we analyzed the items critically and discussed the results with other researchers in our research group. We decided to keep 21 items in total and to go forward with the instrument development process. Our three reasons for this decision are the following: First, as recommended in literature, we aimed to have approximately four to six items per sub-construct (cf. Hair et al. 2006) in the final measure. Second, the three dimensions of effective use are conceptually complex and potentially interrelated, which may confuse raters (PSA<0.6) or cause raters to also choose a similar concept for an item belonging to another dimension of effective use (CSV<0.5). Third, RF includes formative items, which might have added complexity to the sorting process. Although researchers like Helm (2005) demonstrated that it is possible to receive values of PSA and CSV above the suggested cut-off value of 0.6 for formative constructs, it might be the case that the raters in our study were confused by the formative items and therefore, had difficulties in assigning the item to the corresponding construct. For all items, we kept detailed records of revision history and pre-test performance which factor into our overall assessment of our proposed measurement model's quality.

As a next step, we performed a content validity check with three researchers. During that process, we performed a back-translation (Brislin, 1970; 1986) as the questions were needed in German to conduct the item validation within our case company. In an attempt to reduce the number of items and burden for respondents (Hoehle and Venkatesh, 2015), we again dropped three items (resulting in 18) that were highly similar to each other. In addition, we realized that four out of the remaining six items for RF were conceptualized as formative, while the other two are reflective items. The formative items refer to the content's quality, i.e. the faithfulness of the reflection of the real-world domain by data in the system, while the reflective items refer to an individual's trust in the presented content. Finally, we performed a pre-test of the survey with six researchers. After this pre-test, we made minor changes in wording to the items. The resulting pool of items (see Appendix 1) was sufficient to perform the next step in developing the instrument and testing the model.

4.3 Data collection

For the validation of our items, we collected data from two sources: our case company and a panel. In doing so, we prepared two online surveys, whereas one applies the German items for the case company and the other one applies the English items for data collection from an international panel. We decided to conduct the survey in our case company first, as we expected to get only a medium sample size of responses (no more than 100 responses) as BANK's credit service unit has approximately 350 employees that can be invited to participate the survey. In doing so, we were able – if necessary – to adapt the survey for the panel study which is related with high monetary costs. For both studies were distributed an online survey to employees of BANK and the panelists by using Questback – a software for online surveys. To prevent or at least consider possible biases, we employed ex ante and ex post techniques to reduce the threats to validity from the common-method bias. Ex ante to our study, we triangulated the process of item operationalization by gathering qualitative data in form of feedback from BANK's employees and quantitative data on the quality of our items in form of the card sorting method conducted with 108 students. In order to prevent common method bias, we designed the survey in a way that we purely collected data on the endogenous variables and thus, employed only respondents for the various sub-constructs of the dependent variable EU (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003).

We performed the first wave of data collection in December 2014 with all employees at BANK (across all affected business units) that were affected by the implementation of LMS (total 344 employees). Participation in the survey was voluntary and came on top of employees' regular work. Participants were requested to indicate their level of agreement with each item on a 7-point Likert scale (1 [strongly disagree] to 7 [strongly agree]). From these employees 63 valid responses were collected after quality control (response rate 18.3%). We found that non-response bias was not an issue because the sample demographics well represented the "average workforce" at BANK with regard to gender age, and organizational tenure (see Table 1). Non-response was due to voluntariness of the survey as well as the high operational pressure on all employees during the shakedown phase. Thus, the matching demographic profile as well as our data collection over a relatively short time (2 weeks) without official reminders alleviates concerns about response bias (Hoehle and Venkatesh, 2015; Sykes, 2015).

In the second wave, we conducted the data collection by employing an international service provider for online surveys and panels in order to receive a larger sample size than in our case company. Furthermore, the employment of a panel provider enabled us to collect data from a sample being as heterogeneous as possible from multiple organizational contexts. In doing so, we also get some insights regarding data's generalizability. We are aware, that one might argue that an application of web-based research panels can result in panel effects. For instance, Dennis (2001) stated that "panelists' self-reported attitudes and behaviors are changed over time by their regular participation in surveys (Dennis 2001 p. 34). Furthermore, it is often argued that only a specific group of people is interested in being part of a panel (Dennis, 2001). For both examined panel effects, Dennis (2001) noticed that he did "not detected a serious undercurrent of negative panel effects. By taking proper precautions, researchers can enjoy the benefits of online panels and minimize these potential problems" (Dennis 2001 p. 36). We provided the panel provider with a set of criteria describing the targeted respondents before starting the data collection. In particular, we focused on potential respondents that can be classified as knowledge workers (Drucker, 1999). In addition, we declared that the overall set of respondents should cover multiple industries and different educational as well as socio-economic backgrounds in order to balance the demographics of the respondents. We particularly asked the panel provider to balance the set of data with regard to respondents' gender. In addition, we purposefully selected a panel provider whose respondents come from the United Kingdom to ensure not only high validity of our item set, but also comprehensibility with respect to the language. We decided to collect data from knowledge workers who are experienced in using Microsoft Excel because it has been indicated that among identified workarounds Microsoft Excel is the most welcomed (Eckerson and Sherman, 2008) and the toughest system to be replace (Robey, Ross, and Boudreau, 2002). To receive only responses of highly experienced Excel users, we additionally implemented a filter ensuring that respondents are knowledge workers employed in an organization and have high experiences in using Excel.

4.4 Data analysis

For the analysis of our data sets, we used Partial Least Squares Structural Equation Modelling (PLS-SEM) as described by Urbach and Ahlemann (2010) as well as (Hair, Hult, Ringle, and Sarstedt, 2013). We selected PLS-SEM due to three main reasons: First, it does not require a specific type of data distribution. As we conducted the item validation in our case company and by employing a panel service provider, we were initially not sure whether both data sets demonstrate similar data distributions. Second, as we did not expect to get more than 100 responses from our case company, we needed an approach that is feasible for even small data sets. For reasons of comparability, we then also employed PLS-SEM for the larger data set collected in the panel. Third, the sub-construct of RF contains reflective, but also formative items. Consequently, PLS-SEM is most appropriate for the analysis of our data (Hair et al., 2013) and therefore, for the validation of our item sets. For the data analysis, we used SmartPLS 3.2.0 to run the PLS to algorithm and assess the measurement and structural model.

5 Results

5.1 Descriptive statistics

After the completion of both data collections, we first screened the appropriateness of our data by comparing completion times for the surveys as well as by the screening descriptive statistics. Table 1 provides an overview of the descriptive statistics for both data collections. From the data of our BANK case, we removed one “unengaged respondent” from the sample based on an analysis of standard deviation. However, we had to filter many participants from the panel data set. In total, the panel service provider invited 3,230 panelists to participate in our survey. Due to our filter mechanisms 2,346 participants were screened out, meaning that they either had no or limited experience with MS Excel, they could not describe a case of adapting Excel to their needs, they were not employed in an organization, or the gender-related ratio needed to be balanced. From the remaining 884 participants, 111 did not answer and 337 did not complete the questionnaire and thus, were also removed from our overall data set. Finally, we checked our quality criteria in order to receive the final data set. In doing so, we again had to remove more than 150 out of 436 completed responses from the panel data set, as the data did not fit our quality criteria. For the removing of invalid responses, we followed a two-step approach. First, as we used Questback as software for online surveys, we were able to calculate a quality measure based on the median response times of all participants. We decided to remove all responses that have a quality value smaller than 0.25, which means that the participant’s response times were 50% lower than the average of all participants. Considering the median response times, we therefore removed 107 completed questionnaires (329 remaining questionnaires). In a second step, we considered the items that we coded reversely in our survey. In addition, to consider response times, the usage of reverse coded items also enables the detection of low quality responses. Frequently, researchers suggest to use reverse coded items to identify (inter alia insufficient cognitive ability, impaired response accuracy, or actual measurement of a different construct) careless responses (Magazine et al. 1996, p. 247). When respondents answered significantly different on two items that were reversely coded to each other but referred to the same construct, it can be the case that they were careless in their answers and thus, the quality of their overall answers can be doubted. By analyzing the reverse coded items, we therefore again had to remove 48 completed questionnaires (resulting in 281 valid responses) to ensure high quality of our research results.

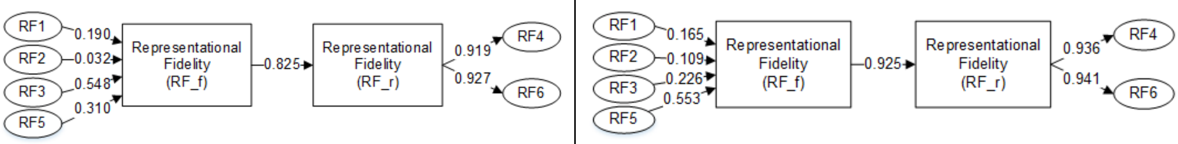
	BANK data	Panel data
Number of invitations / participants/ valid data sets	344/ 65/ 64	3,230/ 436/ 281
Number of female participants	34 (53.1%)	151 (53.7%)
Number of male participants	30 (46.9%)	130 (46.3%)
Average age	36.66 years	42.23 years

Table 1. Descriptive statistics of BANK and Panel data

5.2 Measurement model assessment

As a next step, we assessed our measurement model depicted in Figure 2 and performed several tests to evaluate its validity and reliability (MacKenzie et al. 2011). First, we needed to resolve the Multiple Indicators and Multiple Causes (MIMIC) modeling of RF's items. As stated above, we identified four items that are formatively modeled as they cover the dimensions of content's quality and two items that were reflective modeled as they refer to individual's trust into the presented content. For the resolving, we followed the approach as described by Barki et al. (2007) (referring to Diamantopoulos and Winkelhofer 2001). Before resolving the MIMIC model, we had to ensure that the formative indicators fulfill all quality criteria and thus we had to assess the measurement model for the formative indicators. As depicted in Figure 2, the path coefficients between the formative and reflective modeled constructs of RF are for both data sets (collected at BANK and within the panel) greater than the suggested threshold of 0.8 (Hair et al., 2013). Thus, the path coefficients support the formative constructs' convergent validity. As high correlations between two formative measures are problematic from a methodological and an interpretational perspective, we also assessed the multicollinearity by calculating the variance inflation factor (VIF) (Hair et al., 2013). Researchers suggest a threshold of a VIF smaller than ten indicating that multicollinearity is not problematic (Urbach and Ahlemann, 2010). The VIFs of both data sets do not exceed this threshold. Finally, we conducted a bootstrap algorithm to assess the significance and relevance of our formative indicators. The t-values of the all the outer loadings range between 13.30 and 79.79 for the BANK data set and between 33.17 and 172.40 for the Panel data set. The paths between the formative and reflective constructs are also significant at a 0.001 level (see Figure 2). Thus, all formative indicators are significant at a 0.001 level. Consequently, the formative indicators fulfill all quality criteria enabling us to resolve the MIMIC model by following the descriptions of Barki et al (2007). In doing so, we conducted the PLS algorithm in SmartPLS for RF modeling the formative and reflective measures in two separate constructs (as done in Figure 2). By using the latent variable scores of the two constructs as new measures, we were able to model RF as a reflective construct consisting of two measures. In the following, the measure resulting from the formative indicators is referred to as RF_f and the measure based on the reflective indicators is referred to as RF_r. Both measures are modeled as reflective indicators of the RF construct. Consequently, all items of the resulting measurement model are now modeled as reflective indicators enabling us to assess the measurement model as described by (Hair et al., 2013) and MacKenzie et al. (2011).

BANK | Panel



BANK		Panel	
VIF (RF1) = 2.575	VIF (RF3) = 5.032	VIF (RF1) = 6.512	VIF (RF3) = 5.585
VIF (RF2) = 5.139	VIF (RF5) = 5.875	VIF (RF2) = 8.759	VIF (RF5) = 4.309
t-value = 21.141 (p-value < 0.001)		t-value = 71.821 (p-value < 0.001)	

Figure 2. Assessment of formative measurements for BANK and Panel data set

For the assessment of the measurement model, we first tested the model for indicator reliability. Table 2 summarizes the results and demonstrates that nearly all outer loadings of both data sets are higher than the suggested threshold of 0.708. Only TI5 of the BANK data does not reach the threshold. Since our research has an exploratory character and TI5 of the Panel study did not come below the threshold, we decided to keep the indicator in the measurement model.

Latent Variable	Indicators	Outer Loadings		Composite Reliability		Cronbach's Alpha		AVE	
		BANK	Panel	BANK	Panel	BANK	Panel	BANK	Panel
TI	TI1	0.883	0.815	0.912	0.920	0.887	0.895	0.636	0.657
	TI2	0.761	0.863						
	TI3	0.884	0.830						
	TI4	0.821	0.731						
	TI5	0.607	0.779						
	TI6	0.797	0.837						
RF	RF_f	0.956	0.982	0.954	0.981	0.904	0.961	0.912	0.962
	RF_r	0.954	0.980						
IA	IA1	0.917	0.884	0.962 0.944[1]	0.964 0.936[1]	0.952 0.911[1]	0.955 0.898[1]	0.808 0.850[1]	0.816 0.831[1]
	IA2	0.903	0.924						
	IA3	0.894	0.934						
	IA4	0.901	0.908						
	IA5	0.902	0.888						
	IA6	0.877	0.883						
Suggested Threshold		> 0.708		0.6 – 0.95 (for exploratory research)				> 0.5	

[1] values after removing of IA2, IA4, and IA6

Table 2. Results of the Assessment of the Measurement Model

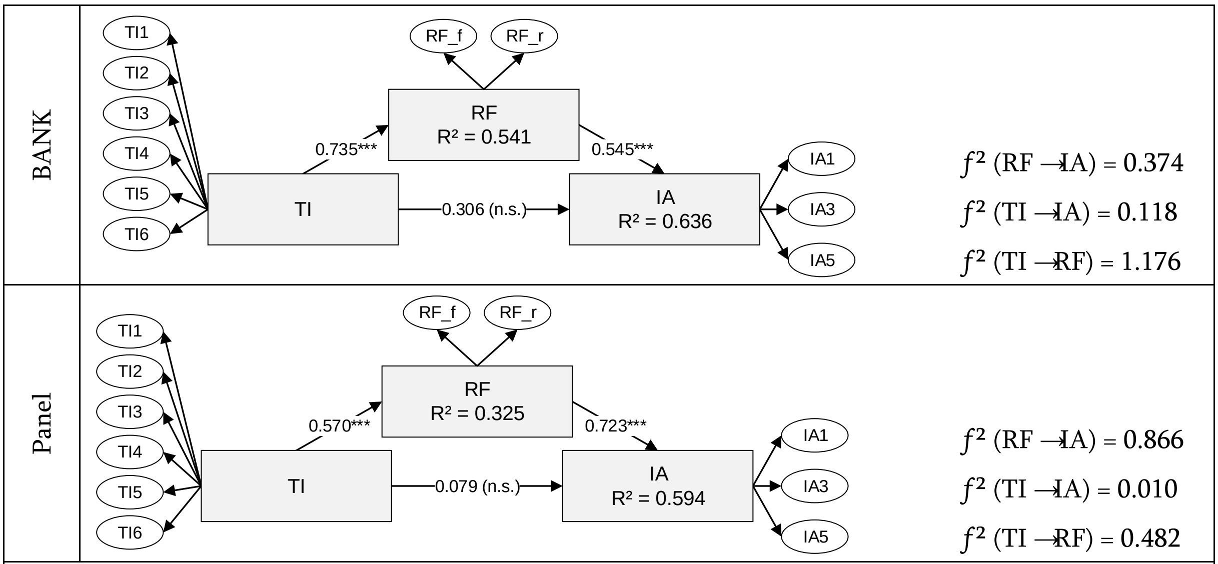
Thus, we can conclude that the indicators of each construct have much in common and therefore reflect the according construct. While the outer loadings enable the assessment of the measurement model on an indicator level, the average variance extracted (AVE) criterion enables the assessment of the model's convergent validity on a construct level. As indicated in Table 2, all AVE values are higher than 0.5 and thus, the particular "construct explains more than a half of the variance of its indicators" (Hair et al. 2013, p. 103). Both, composite reliability and Cronbach's alpha enabled us to assess the model's internal consistency reliability. For both measures, literature suggests thresholds between 0.7 and 0.95 respectively. However, for exploratory research values between 0.6 and 0.7 are also acceptable. Values above 0.95 indicate that items are semantically redundant (Hair et al. 2013). Considering the values summarized in Table 2, especially the composite reliability and Cronbach's alpha values of IA seem to be critical. We, therefore, carefully scanned the individual items and decided to remove IA2, IA4 and IA6 from the measurement model, as each of them bore resemblance to one of the remaining items. In doing so, we reached acceptable values for composite reliability and Cronbach's alpha smaller than 0.95. Finally, we assessed the discriminant validity criterion, which demonstrates that a construct is truly distinct from the other constructs. We used the Fornell-Larcker criterion, where AVE's square root for each construct should be higher than 0.5 and in all cases higher than the variance shared with all other constructs (Fornell and Larcker, 1981). Table 3 demonstrates that the Fornell-Larcker criterion and thereby discriminant validity is fulfilled.

BANK					Panel			
	IA	RF	TI			IA	RF	TI
IA	**0.922**				IA	**0.911**		
RF	0.770	**0.955**			RF	0.768	**0.981**	
TI	0.707	0.735	**0.798**		TI	0.491	0.570	**0.811**

Table 3. Fornell-Larcker Criterion Analysis

5.3 Structural model assessment

In addition to their operationalization, we are also interested in the relationships between the three sub-constructs of effective use (EU). Thus, we assessed the structural model in the next step. Again, we followed the suggestions of Hair et al. (2013). Table 4 summarizes the path coefficients, the significance levels of paths, the explained variances (R^2), and the effect sizes (f^2) for the structural model.



*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; n.s. = not significant

Table 4. Assessment of the Structural Model

As indicated, there is a significant relationship between TI and RF as well as RF and IA for both data sets. As hypothesized by us (and by Burton-Jones and Grange 2013), our data also demonstrate that RF fully mediates the relationship between TI and IA. Consequently, our operationalization of items and the hierarchical structure between the sub-constructs of EU could demonstrate the validity of the assumptions and hypothesis formulated on the EU construct. In addition, our data also indicate that approximately 60% of variances in IA can be explained by RF which can be considered as a substantial effect. Considering the effect sizes of the paths, this observation is supported. While the effect sizes of RF on IA (f^2 = 0.374 / 0.866) and the effect sizes of TI on RF (f^2 = 1.176 / 0.482) can be considered as strong effects, the effect size of TI on IA (f^2 = 0.118 / 0.010) can be considered as moderate respectively weak (Urbach and Ahlemann 2010). However, for the effect sizes the data sets show different results. Thus, more studies are required to provide evidence regarding the hierarchical structure of the three sub-constructs TI, RF, and IA. In sum, all our hypotheses H1 to H3 are supported by our research results. Consequently, we can argue that our findings support the concept of EU and the hierarchical relationship between TI, RF, and IA as defined by Burton-Jones and Grange (2013).

6 Contributions

Drawing on the recent conceptualization of effective use (EU) (Burton-Jones and Grange 2013), we developed a measurement instrument, and conducted an empirical test to advance our understanding of individuals' effective use in an enterprise system implementation (post-adoption) context (at BANK) and in general (within a panel). In answering our research question, we show that there is a hierarchical relationship of transparent interaction (TI), representational fidelity (RF), and informed action (IA). Thus, we show that TI (i.e. the unimpeded access to a system's representations can only facilitate IA if the representations) of the real world in the system faithfully reflect the represented domain. We make several theoretical and practical contributions. From a theoretical perspective, we believe that the key contribution of our work is the operationalization of EU and its constituent sub-constructs. We leveraged the recent conceptualization of EU suggested by Burton-Jones and Grange (2013) and developed an operationalization with all new items for measuring the model. For that purpose, we followed a thorough process as suggested by MacKenzie et al. (2011). To our knowledge, this also is the first instrument to measure this conceptualization of EU and thus adds to the literature of adoption and use of IT that calls for measures of richer IT use concepts (Burton-Jones and Gallivan, 2007; Burton-Jones and Grange, 2013; Goodhue, 2007). As such, the work we present here affords other researchers to draw on our instrument should they choose to engage with EU and its sub-constructs in their empirical work. We also strongly believe that the development of relevant and reliable items is a contribution in its own right. Theoretical constructs are always specified and defined by two things: (1) through the nomological network they belong to and the reciprocal conceptual relationships with surrounding constructs (Suddaby, 2010), and (2) and more importantly for our work, through the observables used to measure them (Bacharach, 1989; Kaplan, 1964). We therefore propose that our results bear the potential to advance our understanding of individuals' use of enterprise systems – and IS in general.

From a practitioner's perspective, organizations are confronted with a more than ever demanding business environment and therefore always strive for higher efficiency in their operations. Ineffective use of the enterprise system after its implementation can undermine these goals. In this context, it is our steadfast belief that the items we suggest can be employed by managers to better understand the key drivers and potential impediments of TI, RF, and IA in practice in their attempt to improve the EU of systems they implement. In the longer term, this can have wide-ranging practical implications. One example is the rethinking of training programs that accompany technology introductions. These might focus less on systems and systems' features, and more on what truly matters to individuals to get these systems to work for them. Similarly, our insights may come to inform future enterprise systems' design, for example in how user interfaces are designed and developed. This could be particularly interesting with regards to the element of IA. The measures for effective use could be employed to assess how well a newly developed interface enables users to take IA.

In order to evaluate these implications, it is important to reflect on a set of important limitations. *First*, we initially focused on the EU of enterprise systems. We believe that the conceptualization of EU by Burton-Jones and Grange (2013) has a good fit with enterprise systems, particularly in the context of our first data collection at BANK. Nonetheless, our initial results are bound to this substantive context and our insights and conceptualizations should be further tested and validated in other contexts to enhance their summative validity (Lee and Baskerville, 2003; Lee and Hubona, 2009). To partially mitigate this limitation, we conducted our second data collection effort with a panel. The respondents in this second effort had various backgrounds and use contexts and, based on our panel provider, were somewhat representative for knowledge workers in the UK. Furthermore, we used the broadly used tool Excel as the reference for data collection to indicate the generalizability of our developed measures for TI, RF, and IA. *Second*, it is important to recall that our initial conceptualization is temporally bound to the shakedown phase (Markus and Tanis, 2000). We referred to this context for the selection of panel respondents. Disruptions, shock, and negative reactions are at peak during the shakedown phase (Bala and Venkatesh, 2013; Markus and Tanis, 2000; Morris, Venkatesh, and Davis, 2002). This predestines the shakedown phase for studying the emergence of EU's antecedents. Nevertheless, future research may have to study EU outside the shakedown phase as well. Particularly, we suggest that investigating how EU is disrupted by a significant IT event may warrant future research's attention. Also, the investigation of EU in seemingly stable conditions is a field deserving future attention. *Third*, actually measuring EU needs further attention by researchers. In our study, we focused on perceptions as a measure of EU. While this is perhaps a needed first step, we suggest that future research should develop ideas for objective measures (e.g., based on documented user data such as log files). Although we have empirically well-grounded findings that we also triangulated with qualitative data for the BANK study (e.g., interviews with group leaders and managers, indicating that EU actually did increase over the duration of the post-adoption phase), we were restricted to collecting data about EU with a survey instrument in both instances. While our larger panel study helps to extend and generalize our findings, future studies should build on our findings and further validate our measures and approach.

Appendix

ID	Item	Measurement in Study
TI1	I find system very cumbersome to use.	reflective
TI2	When using system interface it requires a lot of (mental) effort.	reflective
TI3	Overall, I believe that system is easy to use.	Reflective, reverse coded
TI4	I would imagine that most people would learn to use system very quickly.	Reflective, reverse coded
TI5	When using it I find it difficult to obtain the content that I need because of system's interface.	reflective
TI6	I find the system unnecessarily complex.	reflective
RF1	When I use system, I find that the content (data, report information etc.) it provides me was sufficiently correct.	formative
RF2	When I use system, I find that the content (data, report information etc.) it provides me was sufficiently complete.	formative
RF3	When I use system, I find that the content (data, report information etc.) it provides me was sufficiently meaningful.	formative
RF4	When I use system, I am confident that the content the system provides is a correct representation of the business case (e.g. loan contract data) at hand.	reflective
RF5	When I use system, I find that the content (data, report information etc.) it provides me was sufficiently clear.	formative
RF6	When I use system, I find that I can rely on it to process the data I entered correctly.	reflective
IA1	I use system because it supports me in successfully performing my work.	reflective
IA2	I act upon the information that is provided by system because it helps me to effectively perform my work.	reflective
IA3	When I obtain information from system I can act upon it to effectively perform my task (e.g., complete my process).	reflective
IA4	System is the adequate system to effectively do my work (finish my work in time and quality).	reflective
IA5	I can leverage system's functionality to effectively perform my work.	reflective
IA6	I leverage system's functionality to successfully perform my tasks/processes.	reflective

Appendix 1. Measurement Items of Effective Use's Sub-Constructs

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