Influential characteristics of enterprise information system user interfaces

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Influential Characteristics of Enterprise Information System User Interfaces

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End-user acceptance is considered as a significant factor influencing the success of enterprise information system (EIS) implementations and operations. This study conceptualizes three aspects of EIS user interfaces (UIs), namely information overload, control familiarity, and UI fit, and proposes a model to understand their effect on two major factors that are considered to influence the end-user acceptance of these systems: EIS end user’s performance expectancy and effort expectancy. We developed a theoretical model and multiitem scales for the proposed EIS UI characteristics and tested the model empirically with data from a survey performed with a sample of 98 EIS end users. The results from our test provide evidence for the key role that EIS UI design plays in the end user’s performance and effort expectancy.
used for the survey. Then, we present the survey and results, which are followed by the discussions on the findings and their implications for research and practice. Finally, we conclude with limitations and outlook for future research.

Background and related research

Technology acceptance

The studies on the utilization of information technology have gained momentum with the emergence of technology acceptance model (TAM) and its derivatives. The TAM is based on the principles of the Theory of Reasoned Action to explain and predict the behaviors of organization’s individuals in a specific situation [11]. It suggests that when users are presented a new technology, they develop an attitude toward using it based on its perceived usefulness and perceived ease of use [11]. The TAM has been studied, expanded, and upgraded [62]. A major upgrade to the TAM is the UTAUT model proposed by Venkatesh et al. [63]. The UTAUT aimed at consolidating the constructs from TAM and seven other models that the earlier research had employed to explain technology usage behavior.

The UTAUT model suggests that the end-user usage of information technology is influenced mainly by four factors: PE, EE, social influence, and facilitating conditions. The first three constructs are direct determinants of usage intention and behavior, while the fourth is a direct determinant of actual usage behavior. Furthermore, these constructs are moderated by gender, age, experience, and voluntariness of use. PE is the degree to which an individual believes that using the system will help him or her to attain gains in job performance. EE is the level of ease associated with the use of the system. Social influence is the degree to which an individual perceives that important others believe he or she should use the new system. Finally, facilitating conditions relate to the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system [63].

The UTAUT model has been validated in a longitudinal study and was found to outperform each of the individual models that it incorporated as its basis [63]. The study found the model to account for 70% of the variance in behavioral intention (adjusted $R^2$).

Since its launch, the model has been widely accepted and applied in the IS research [65]. It has been applied as is for validation (e.g., [48]), with other theories (e.g., [69]), or extended to study a variety of technologies in diverse settings (e.g., [35,66]). For instance, Pynoo et al. [48] applied the original UTAUT to examine the use of a digital learning environment in secondary schools. The study confirms the model’s ability to explain (to a large extent) the users’ acceptance of related technologies. The UTAUT has also been integrated with theoretical perspectives, such as the task technology fit (TTF) [69] or initial trust model [44]. The research has also extended UTAUT in several dimensions with exogenous and endogenous mechanisms. For instance, Wang et al. [66] studied perceived innovativeness with IT and computer self-efficacy as two exogenous variables and knowledge sharing outcome expectancy as an endogenous mechanism directly or indirectly influencing end users’ intentions to use technology. The proliferation and diffusion of new information technologies, such as EIS, has also contributed to the growth of UTAUT-based research [57]. The study [65] provides a detailed account of works that applied, integrated, or extended the UTAUT model.

Usability of EIS UIs

Several researchers have studied the usability problems of EIS and shown critical shortcomings in EIS usability. However, empirical studies that investigate the degree of impact of these usability problems on the end-user acceptance of EIS is limited. In the following paragraphs, we briefly discuss these works.

To address the concerns regarding the UI characteristics, Singh and Wesson [54] proposed usability heuristics that could be used in designing ERP UIs. Taking general usability heuristics [38,53] of the HCI research field as a basis, they proposed ERP usability heuristics that include navigation (navigability), (appropriateness of) presentation, (degree of) task support, learnability, and (ease of) interface customization to ensure alignment between the system and user needs. Examples of usability problems include the complexity of visual layout, outputs that are difficult to understand and interpret, and unintuitive UI of the system. Their conclusions are based on cognitive walkthroughs of three usability experts evaluating a limited sample of ERP systems. A similar study was performed by Faisal et al. [16], suggesting usability heuristics for ERP systems through qualitative research of literature on usability.

Parks [47] compared task time and task success of two versions of an ERP system UI (one being a simplified version of the other) with 38 users and concludes that the ERP system UI complexity has a significant effect on task time. Scholtz et al. [51] also studied the usability of ERP systems and confirmed the usability issues related to navigation, inadequate support for the end-user tasks, IO, and complexity of the presentation.

The abovementioned studies typically use usability testing techniques (such as case studies, ethnography, interviews, time diaries) with the goal to find flaws in a specific EIS UI and help designers improve that interface, without an explicit claim for generalizability [51]. They highlight problems relevant to EIS UIs and capture a number of essential UI characteristics that are valuable as points of departure for our work. However, they require extensions beyond the evaluation of a single ERP system with small user groups in relation to a certain usage scenario to generalize results regarding their influence on user acceptance.

EIS UIs and acceptance

Calisir and Calisir [8] investigated the relation between the perceived usefulness and user satisfaction in the ERP system use and tested their model on a sample of 51 ERP end users. Their study considered a number of ERP UI characteristics, including, for example, learnability and minimal memory load. The results confirm that perceived usefulness and learnability are significant determinants of ERP system user satisfaction. Ozen and Basoglu [45] applied the concept of usefulness and ease of use as predictors of satisfaction. They studied selected UI characteristics of ERP systems, such as navigation (navigability), minimal memory load and simplicity and investigated
their effects on user satisfaction. In line with the conclusions reached by Calisir et al. [8], the results of a survey among 35 ERP end users indicate that the UI design characteristics are significant determinants of end-user satisfaction with the ERP systems. Despite certain limitations (such as the sample size), both studies confirmed the importance of appropriate UI design on user satisfaction. However, the relationship between user satisfaction and user acceptance, as well as the relation with particular EIS UI characteristics, remained unaddressed.

A number of studies ([30,33,40] investigate the UI as a pooled factor integrated into the TAM [11]. Although the factor incorporates only a limited set of generic characteristics (i.e., the comfort in reading screen design due to font style, color, layout, etc., ease of navigation, quality in interaction, and overall satisfaction), it is found to have a strong correlation with the perceived ease of use [30,33,40] and perceived usefulness [30].

Youngberg et al. [68] examined the technology acceptance variables for (autonomous) end users of an ERP component to understand significant variables’ correlation and predictive effects on perceived usefulness and usage. The study hints at factors, such as the perceived technology fit, use of end-user terminology for the EIS, and EIS-specific training and support, to have a significant influence on ERP acceptance. The study by Sternad et al. [55] also confirms these findings to a large extent with additional constructs. These factors closely relate to the end-user perception of EIS interface and its specific characteristics, which are yet to be investigated.

Research design

In this study, we aim to conceptualize some key aspects of EIS UIs that are considered to influence the PE and EE of end users from these systems. Figure 1 summarizes the research steps that we followed to address this research objective.

As a first step, based on the relevant background in the fields of HCI and user psychology, we defined three aspects of the EIS UIs that potentially influence how end users perceive EIS’ usefulness and ease of use. These aspects are the IO on the EIS UI, the familiarity of the controls used in the EIS UI to the end user (CF), and the degree of fitness between the EIS UI and end-user needs (user interface fit (UIF)). Next, we proposed a model that hypothesizes these three aspects as important antecedents of end user’s PE (perceived usefulness) and EE (perceived ease of use), which are known to impact EIS acceptance and use. We discuss these aspects and our research model in detail in the next section.

For the assessment of the proposed model, we used the survey as our primary research method and developed a questionnaire (Step 2 in Figure 1). For three constructs of the model, the questionnaire items that are validated in prior research were adapted with minor changes to reflect the artifact (EIS) being assessed. For the remaining two constructs, we developed new questionnaire items (multititem scales) following a step-by-step process applied in [11,56]. Accordingly, we first generated candidate scale items for these constructs. Next, we performed interviews with experts for clustering scale items, which was followed by a ranking survey with a number of EIS users for item refinement. For the final version of the multititem scales, we performed a pretest survey with EIS end users to test items for reliability and construct validity.

Finally, we conducted a survey of 98 EIS users in order to evaluate the proposed model using the finalized questionnaire items (Step 3 in Figure 1). In the following sections, we elaborate on the steps that we followed in developing and validating our measurement instrument, and in testing its underlying theoretical model.

Hypotheses and proposed model

The subsequent sections present the theoretical background for the proposed EIS UI aspects (IO, CF, and UIF) and the hypotheses regarding their influence end-user acceptance through PE and EE.

Information overload

Information may enable a human task to be performed more efficiently and effectively, but only when the information is relevant to the task at hand [25]. The accuracy and usefulness of information have become more important in today’s digital era [6]. The advances made in information and communication technology (ICT) have intensified the perceptions and the actual effects of IO [15,25]. Studies show that a workplace that contains just the elements that are needed for a given task increases the employee productivity [36]. Similarly, IO is found to be negatively related to individuals’ ability to effectively deal with ICT [5].
IO on a UI relates to the degree in which unnecessary, task-irrelevant information is placed on the interface. Accordingly, we can define IO on an EIS interface as “the extent to which an end user perceives that the EIS UI contains elements (such as labels, text boxes, menus, buttons, symbols, etc.) that are never or rarely used to accomplish his or her tasks.”

With the inherent complexity of the enterprise systems, the UIs of these systems have been criticized for having excessive information and interface elements [13,20]. The information that has a marginal likelihood of conveying value to the achievement of a task objective may hamper the performance of the task execution.

Minimalist design, which is characterized by providing only relevant information to the user, is one of the key heuristics for UI design. Interfaces should not contain information that is irrelevant or rarely needed, since this extra unit of information competes with relevant information and reduces its relative visibility [38]. The criterion of minimalist design, or avoiding IO, has been part of various heuristic evaluation methods since the early 1990s. The most well-known list of heuristics has been developed by Nielsen and Molich [39]. Taking a more holistic approach, Gerhardt-Powals [18] developed a set of cognitive principles for enhancing computer performance, similar to those of Nielsen and Molich. Gerhardt-Powals stresses the design principle that information displays should only include the relevant information needed by a user at a given time. Although these heuristic principles testify to the importance of simplicity of the information display, in practice there may be difficult design choices to be made between simplicity of the interface and the need to present a sufficient level of information to the user to enable intelligent choices and support relevant action. The perceived degree of EIS UI information overload thus relates to the complexity of these interfaces, which has become a construct used for the usability studies of ERP systems [31,47].

Accordingly, we hypothesize that the IO on EIS UIs has a negative influence on PE and EE. The relevant hypotheses are:

- **H1:** Information overload (IO) on the EIS user interface has a negative effect on the performance expectancy (PE).
- **H2:** Information overload (IO) on the EIS user interface has a negative effect on the effort expectancy (EE).

### Control familiarity

Research in psychology suggests that familiar patterns are easier to recognize than less familiar patterns [4,34]. Use of familiar structures can generate in the users’ minds a series of connections to past experiences, enabling them to form an accurate sense of the system’s capabilities and limitations [61]. The system should match, as much as possible, the real world that the user lives in [38]. Its interface should exhibit the words, phrases, and concepts familiar to the user, rather than system-oriented terms [53]. It should reflect the jargon of the particular business domain in which the organization is operating, so as to “speak the user’s language” [26,38,54]. As confirmed by the studies in the field of HCI, familiarity with UIs can have substantial impact on the user perception of the interfaces [20].

In this context, we define CF as “the extent to which an end user perceives the UI of the EIS, regarding control, navigation, orientation and labeling, as familiar to him/her.” Accordingly, we posit that the familiarity of the EIS UI controls has a positive influence on the PE and EE:

- **H3:** Control familiarity (CF) of the EIS user interface has a positive effect on the performance expectancy (PE).
- **H4:** Control familiarity (CF) of the EIS user interface has a positive effect on the effort expectancy (EE).

### User interface fit

UIF concerns the degree of alignment between the UI and the organizational and user needs [27]. The “fit” concept is key in the TTF model, which involves the matching of the capabilities of the technology to the demands of the task, that is, the ability of technology to support a task [19]. The TTF model suggests that the technology will be used only if the functions available to the user fit the work activities of the user. Rational users will choose the technology that helps them to complete the task with the greatest net benefit [14]. This is partially because the fit should lead to reduced levels of strain due to ICT [5]. The term “fit” also appears in the studies on organizational theories in the form of “correspondence.” For example, the correspondence between the abilities of an individual and the ability requirements of a job in determining an individual’s suitability for the job is an important element in the theory of work adjustment [19].

The studies on data representation and UI design involve the fit concept and conclude that the best representation depends on task requirements [58]. The degree of content relevance on a UI influences its perceived usability [1]. An empirical study by Hong and Kim [27] finds the fit of the ERP UI to the key work activities of the users as one of the significant determinants of ERP implementation success [27].

We define the UIF aspect in this context as “the extent to which an end user of an EIS perceives that the EIS UI matches the demands of his/her tasks”; in other words, the perceived degree to which the EIS UI enables end users to accomplish their tasks connected with the EIS. Systems that are perceived as providing features and support that fit the requirements of a task are considered to have a high UIF level and contribute to the task performance [19]. Accordingly, we propose that an EIS UI can be characterized by the level of fit to its intended task, and the level of UIF is positively correlated with the PE and EE.

- **H5:** EIS user interface fit (UIF) has positive effect on performance expectancy (PE).
- **H6:** EIS user interface fit (UIF) has positive effect on effort expectancy (EE).

### Proposed model

The proposed model is depicted in Figure 2. Overall, we hypothesize that the aforementioned EIS UI aspects determine, in part, two determinants of behavioral intention toward using technology (as proposed by the UTAUT model), namely PE and EE. We hypothesize that the user beliefs about the
usefulness (PE) and ease of use (EE) of an EIS are developed partly from a rational evaluation of EIS UI characteristics and the tasks for which it could be used.

**Questionnaire and multi-item scales**

We developed a questionnaire for the assessment of our research model depicted in Figure 2. In the following subsections, we first present the validated questionnaire items that we adapted from the existing research. This is followed by the description of the steps that we followed in developing new scales for two constructs that lacked validated items in the existing literature.

**Adapted scale items**

For three constructs of the model, namely, PE, EE, and UIF, we adapted the validated items in the existing research. The UTAUT is a well-established model with published items for each construct [63]. Therefore, the items for the PE and EE were used with only minor changes to reflect the EIS being assessed. (For each construct, we selected three original scale items that have the highest factor loadings and replaced the term “system” in the original item with the term “EIS” to reflect the research performed.)

The items for the UIF were also adopted from the existing literature on TTF [27] with minor changes in the wording regarding the use of EIS (more specifically, the term ERP in the original items was replaced with the term “EIS” to represent a wider set of such systems). Table 1 lists the adapted items for these constructs.

**Development of new scale items**

Unlike PE, EE, and UIF, the IO and CF constructs did not have validated items in the existing research. Hence, we developed and validated the questionnaire items for these constructs following the process applied in [11] and [56].

**Generating candidate scale items**

Careful selection of the initial questionnaire items helps to assure the content validity of the questionnaire [41]. Previous research shows that we needed at least 10 items for each construct to achieve sufficient reliability [11]. Adding one more item for possible item elimination, we generated 11 candidate items for each construct based on the conceptual definitions of these constructs and a review of literature. Table 2 and Table 3 list these candidate items for IO and CF constructs, respectively.

**Interviews with experts for scale item clustering**

The candidate items went through a series of tests for refinements. First, we interviewed with an academic expert on HCI, and with four EIS users (each with more than 6 years of experience in the use and implementation of multiple EIS), to classify candidate scale items. Eleven candidate items were classified into three categories (A, B, C), each indicating a particular subcharacteristic under a construct. The objective was to decrease the chance of having excess coverage of some areas of meaning within the content domain and not enough of another. This is also because it gives the possibility to remove items where excess coverage or less relevancy is suggested and add items where inadequate coverage is indicated.

As shown in Table 2, three categories of subcharacteristics were defined for the IO. The first category (A) relates to the presence of excessive UI elements, the second (B) to the perceived hindrance of productivity due to UI elements, and the third (C) to the perceived degree of utility of UI elements. The CF (Table 3) also fell into three categories. The first category (A) relates to the perceived degree of acquaintance with the UI elements, the second (B) to the perceived degree of familiarity with the jargon used for the UI elements, and the third (C) to the perceived degree of available support for UI element use.

![Figure 2. The proposed model (parts that are greyed out are kept outside the scope of this study).](image-url)
to rank the degree to which each item matches the construct’s definition. Table 2 and Table 3 present the questionnaire items for IO and CF constructs, respectively. The survey yielded eight items for each construct that best fit to their definitions.

Pretest survey with EIS end users for final set of items
As a final step in the development of new items, we performed a pretest survey to empirically test the constructs and items for reliability and construct validity and further refine the items. The study involved two learning management systems (LMSs), which were used to administer and manage the courses in a European university that had over 13,000 students and staff members. The LMS1 was the legacy system to be replaced by the new system (LMS2), which had already been in operation for a number of courses as pilot implementations.

Using the eight items retained in our previous step for the IO and CF, and those that we have adopted from the existing research for the UIF, PE, and EE, we developed an online questionnaire. We asked graduate students that have been using either of the two systems for their response. The questionnaire used 7-point Likert scale per item. The responses were obtained from 154 users, of which 102 were LMS1 and 52 were LMS2 users. The respondents on the average had 8 months of experience with LMS1 and 6 months of experience with LMS2.

We performed a confirmatory factor analysis through partial least squares (PLS) using SmartPLS (version 3.2.6). Path weighting scheme with 300 interactions was applied. Factor loadings of the items to all factors are depicted in Table 4.

For the final set of items, we choose three items per construct, each item representing a single category (A, B, and C) of the construct. As the variables are highly correlated with each other (Pearson’s r > 0.7) and fairly uncorrelated with other variables, three-item scales were considered sufficient and reliable [67].

We repeated the confirmatory factor analysis with three-item constructs, which resulted in higher factor loadings to the particular common factor as expected. Table 5 shows the factor loadings after the refinement.

Table 6 shows the results of the reliability and validity analysis of the pretest survey. The internal consistency reliability was assessed using Cronbach’s alpha coefficients. The results indicated sufficient reliability as the values were above 0.70, which is considered acceptable for internal consistency reliability [41].

As shown in Table 6, AVE (average variance extracted) values are higher than 0.5 supporting good convergent validity of the scale items [22]. Similarly, the square roots of AVE values for the constructs were higher than the correlations between constructs, which supports a good discriminant validity of the scale items. The results of the tests on the data resulted from the pretest confirmed the reliability and the construct validity of the constructs and the items that are used to measure them.

Survey study

Data collection and demographics
The final survey study was performed to evaluate the proposed model using the items resulted from the pretest. The instrument used for the survey is given in the Appendix.

Table 2. Questionnaire items for control familiarity (CF).

<table>
<thead>
<tr>
<th>Question</th>
<th>Ranking score</th>
<th>Category</th>
<th>Selected for pretest?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF1 I am familiar with the control provided via the EIS user interface.</td>
<td>8.83</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>CF2 I am familiar with the functionalities of the EIS user interface elements.</td>
<td>8.67</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>CF3 The control of the EIS user interface seems familiar to me.</td>
<td>6.67</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>CF4 The EIS user interface “speaks my language” (it uses well-known terminology).</td>
<td>6.63</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>CF5 I am familiar with the terminology used by the EIS user interface.</td>
<td>6.17</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>CF6 Tags and labels of the EIS interface elements are familiar to me.</td>
<td>6.17</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>CF7 Finding my way in the EIS user interface is familiar to me.</td>
<td>5.67</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td>CF8 The EIS user interface gives me familiar feedback.</td>
<td>5.33</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td>CF9 I am familiar with the guidance provided by the EIS user interface during my work.</td>
<td>4.33</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>CF10 The control shortcuts and inputs used on the EIS user interface (Ctrl + c, Ctrl + v, Alt + F4, Enter, Esc etc.) are familiar to me.</td>
<td>4.00</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>CF11 I have to frequently refer to the help function to learn about control of my EIS.</td>
<td>3.83</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Questionnaire items for information overload (IO).

<table>
<thead>
<tr>
<th>Question</th>
<th>Ranking score</th>
<th>Category</th>
<th>Selected for pretest?</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO1 My EIS user interface contains many user interface elements that I rarely use.</td>
<td>7.88</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>IO2 My EIS contains plenty of the user interface elements that I do not need.</td>
<td>6.88</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>IO3 I am disturbed by unnecessary user interface elements.</td>
<td>6.63</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>IO4 The unnecessary user interface elements are disturbing me in my work.</td>
<td>6.50</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>IO5 My EIS user interface contains much information that I rarely use.</td>
<td>6.50</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>IO6 My work would be more productive if I did not have to face unnecessary information present on the user interface of my EIS.</td>
<td>5.58</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>IO7 My EIS contains much more user interface elements than I need.</td>
<td>5.63</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>IO8 I do not know what most of the user interface elements are used for.</td>
<td>5.63</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td>IO9 I never use most of the functionalities offered by my EIS user interface.</td>
<td>5.00</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>IO10 While I am working with my EIS, my screen is full of user interface elements that I rarely need.</td>
<td>4.75</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>IO11 I do not know what functionalities most of the user interface elements have because I do not need them for my work.</td>
<td>4.75</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

Ranking survey for item refinement
Next, we performed a ranking survey to refine the items and further enhance the content validity by assessing the fit between candidate items and the definitions of the constructs they are intended to measure. We conducted the ranking survey with a sample of eight EIS users, which can be considered experienced (with minimum 6 and on average 9 years of experience in using EIS). We asked the participants, through an online questionnaire,
Table 4. Factor loadings before item refinement.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>IO</th>
<th>CF</th>
<th>UIF</th>
<th>PE</th>
<th>EE</th>
<th>Pretest rank</th>
<th>Category</th>
<th>Selected for final survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information overload (IO)</td>
<td>IO1</td>
<td>0.74</td>
<td>-0.16</td>
<td>-0.16</td>
<td>-0.25</td>
<td>-0.16</td>
<td>6</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO2</td>
<td>0.80</td>
<td>-0.13</td>
<td>-0.11</td>
<td>-0.27</td>
<td>-0.14</td>
<td>1</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO3</td>
<td>0.77</td>
<td>-0.18</td>
<td>-0.16</td>
<td>-0.21</td>
<td>-0.23</td>
<td>2</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO4</td>
<td>0.76</td>
<td>-0.04</td>
<td>-0.11</td>
<td>-0.21</td>
<td>-0.23</td>
<td>4</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO5</td>
<td>0.76</td>
<td>-0.12</td>
<td>-0.10</td>
<td>-0.30</td>
<td>-0.12</td>
<td>3</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO6</td>
<td>0.75</td>
<td>-0.07</td>
<td>-0.24</td>
<td>-0.25</td>
<td>-0.27</td>
<td>5</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO7</td>
<td>0.74</td>
<td>-0.03</td>
<td>-0.12</td>
<td>-0.23</td>
<td>-0.05</td>
<td>7</td>
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<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO8</td>
<td>0.57</td>
<td>-0.17</td>
<td>-0.10</td>
<td>-0.18</td>
<td>-0.13</td>
<td>8</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td>Control familiarity (CF)</td>
<td>CF1</td>
<td>0.11</td>
<td>0.70</td>
<td>0.23</td>
<td>0.15</td>
<td>0.29</td>
<td>7</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF2</td>
<td>0.03</td>
<td>0.68</td>
<td>0.21</td>
<td>0.17</td>
<td>0.27</td>
<td>8</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF3</td>
<td>-0.12</td>
<td>0.79</td>
<td>0.35</td>
<td>0.24</td>
<td>0.30</td>
<td>4</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF4</td>
<td>-0.15</td>
<td>0.75</td>
<td>0.33</td>
<td>0.36</td>
<td>0.40</td>
<td>6</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF5</td>
<td>-0.09</td>
<td>0.82</td>
<td>0.26</td>
<td>0.23</td>
<td>0.37</td>
<td>2</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF6</td>
<td>-0.20</td>
<td>0.82</td>
<td>0.31</td>
<td>0.32</td>
<td>0.36</td>
<td>3</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF7</td>
<td>-0.19</td>
<td>0.86</td>
<td>0.44</td>
<td>0.34</td>
<td>0.48</td>
<td>1</td>
<td>C</td>
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<td></td>
<td>CF8</td>
<td>-0.18</td>
<td>0.76</td>
<td>0.48</td>
<td>0.36</td>
<td>0.47</td>
<td>5</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td>User interface fit (UIF)</td>
<td>UIF1</td>
<td>-0.14</td>
<td>0.40</td>
<td>0.88</td>
<td>0.39</td>
<td>0.57</td>
<td>3</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>UIF2</td>
<td>-0.16</td>
<td>0.42</td>
<td>0.92</td>
<td>0.46</td>
<td>0.55</td>
<td>1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>UIF3</td>
<td>-0.22</td>
<td>0.38</td>
<td>0.92</td>
<td>0.50</td>
<td>0.57</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Performance expectancy (PE)</td>
<td>PE1</td>
<td>-0.34</td>
<td>0.24</td>
<td>0.40</td>
<td>0.78</td>
<td>0.37</td>
<td>3</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>PE2</td>
<td>-0.26</td>
<td>0.38</td>
<td>0.43</td>
<td>0.88</td>
<td>0.45</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>PE3</td>
<td>-0.24</td>
<td>0.31</td>
<td>0.44</td>
<td>0.88</td>
<td>0.39</td>
<td>1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Effort expectancy (EE)</td>
<td>EE1</td>
<td>-0.20</td>
<td>0.30</td>
<td>0.51</td>
<td>0.39</td>
<td>0.84</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>-0.19</td>
<td>0.43</td>
<td>0.61</td>
<td>0.47</td>
<td>0.87</td>
<td>1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>-0.17</td>
<td>0.47</td>
<td>0.36</td>
<td>0.28</td>
<td>0.71</td>
<td>3</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*We chose three items per construct each representing a single category (A, B, C). However, for the IO construct, the item representing category C (IO8) was not chosen as it had considerably low factor loading (<0.7), which was also lower when compared to the loadings of the remaining items. Accordingly, we selected a second item from category A, and chose IOS, as it had the next highest factor loading among the remaining items. Boldface indicates outer loadings.

Table 5. Factor loadings after item refinement.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
<th>IO</th>
<th>CF</th>
<th>UIF</th>
<th>PE</th>
<th>EE</th>
<th>Pretest rank</th>
<th>Category</th>
<th>Selected for final survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information overload (IO)</td>
<td>IO1</td>
<td>0.86</td>
<td>-0.15</td>
<td>-0.11</td>
<td>-0.27</td>
<td>-0.14</td>
<td>6</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO2</td>
<td>0.79</td>
<td>-0.22</td>
<td>-0.16</td>
<td>-0.21</td>
<td>-0.23</td>
<td>1</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IO3</td>
<td>0.84</td>
<td>-0.10</td>
<td>-0.10</td>
<td>-0.30</td>
<td>-0.12</td>
<td>2</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF1</td>
<td>-0.14</td>
<td>0.84</td>
<td>0.35</td>
<td>0.24</td>
<td>0.30</td>
<td>3</td>
<td>C</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF2</td>
<td>-0.11</td>
<td>0.83</td>
<td>0.26</td>
<td>0.23</td>
<td>0.36</td>
<td>4</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>CF3</td>
<td>-0.22</td>
<td>0.91</td>
<td>0.44</td>
<td>0.34</td>
<td>0.47</td>
<td>5</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>UIF1</td>
<td>-0.13</td>
<td>0.36</td>
<td>0.88</td>
<td>0.39</td>
<td>0.58</td>
<td>6</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>UIF2</td>
<td>-0.11</td>
<td>0.43</td>
<td>0.52</td>
<td>0.46</td>
<td>0.55</td>
<td>7</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>UIF3</td>
<td>-0.16</td>
<td>0.34</td>
<td>0.92</td>
<td>0.50</td>
<td>0.57</td>
<td>8</td>
<td>B</td>
<td>✓</td>
</tr>
<tr>
<td>Performance expectancy (PE)</td>
<td>PE1</td>
<td>-0.30</td>
<td>0.21</td>
<td>0.40</td>
<td>0.78</td>
<td>0.37</td>
<td>9</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>PE2</td>
<td>-0.26</td>
<td>0.35</td>
<td>0.43</td>
<td>0.88</td>
<td>0.45</td>
<td>10</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>PE3</td>
<td>-0.25</td>
<td>0.24</td>
<td>0.44</td>
<td>0.88</td>
<td>0.39</td>
<td>11</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td>Effort expectancy (EE)</td>
<td>EE1</td>
<td>-0.18</td>
<td>0.29</td>
<td>0.51</td>
<td>0.39</td>
<td>0.84</td>
<td>12</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>-0.18</td>
<td>0.38</td>
<td>0.61</td>
<td>0.47</td>
<td>0.88</td>
<td>13</td>
<td>A</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>-0.11</td>
<td>0.45</td>
<td>0.36</td>
<td>0.28</td>
<td>0.70</td>
<td>14</td>
<td>A</td>
<td>✓</td>
</tr>
</tbody>
</table>

Boldface indicates outer loadings.

We directly contacted companies operating in Czech Republic, The Netherlands, and Turkey through e-mail invitations sent to the companies’ official contact addresses or by filling out the contact forms on their web sites (the selection of these countries are due to authors’ affiliations). We did not explicitly indicate our research objective in invitations in order to reduce the risk for bias in responses. We gathered 98 responses directly from the EIS end users working in 28 different companies, and many of which operate in Czech Republic (88%).

Table 7 presents the demographics of the respondents, including their age, gender, their experience with the EIS that they evaluated for the survey study, and the type and vendor of the EIS that they evaluated. It also shows the breakdown of means for all model constructs. As shown in the table, the majority of the respondents were at age between 21 and 40. In terms of the EIS type, the ERP systems constituted around 80% of the EIS that were subject to the survey study. Aligned with the EIS market structure, SAP systems dominated the EIS that were assessed by the respondents. However, the suppliers of the enterprise systems that were other than the mainstream vendors constituted a significant portion of the responses.

Results

We applied the same methods and tools that we used in the pretest in conducting our analyses with the gathered responses from the survey (i.e., a confirmatory factor analysis through PLS using SmartPLS, v.3.2.6). First, we retested the proposed constructs for reliability and validity. The values presented in Table 8 indicate higher reliability and validity than those indicated by the values obtained in the pretest.

The values for Cronbach’s alpha coefficients ranged between 0.80 (for IO) and 0.97 (for UIF) (the values for the all constructs are depicted in the first column in Table 8). These values indicate (very) good reliability for internal consistency [41]. AVE coefficients were higher than 0.5 supporting good convergent validity of the constructs (the lowest being 0.72 for IO).
The square roots of AVE were higher than all the correlations between constructs supporting good discriminant validity.

The data sample was also tested for common method variance (CMV) using marker technique [32] and Harman’s test [23]. The tests indicated satisfactory results. In addition, the proposed model was tested for multicollinearity using VIF coefficient [43], which also suggested satisfactory results. In the overall, the tests showed no significant reason to consider the collected data as invalid, unreliable, or unusable in terms of validity, reliability, multicollinearity, or the presence of CMV.

Figure 3 presents the results of our analyses including all path coefficients and their significance as estimated by PLS. As shown in the figure, except the path between CF and PE, all path coefficients are significant at either 0.01 or 0.001. The adjusted $R^2$ values are 0.68 and 0.50 for EE and PE, respectively.

---

2We used the “voluntariness of use” as the marker, which is theoretically unrelated to the other factors measured by this study. The highest correlation between the marker and theoretically unrelated variables was 0.20, which results in 4% of shared variance that could be theoretically assigned to CMV. A single factor excluding any rotation was extracted. This factor did not explain majority of variance, thus supporting low influence of common method variance according to Harman’s test.

3No VIF coefficient was higher than 2.
Figure 3. Results of the analyses. Coefficients are standardized regression coefficients $\beta$; *$p < 0.01$.

Discussion

The main objective of this study was to identify potentially influencing aspects of EIS UIs and assess their influence on the end user’s PE and EE—two major factors that are considered to contribute to end-user acceptance of such systems in accordance with the UTAUT model. We have identified three aspects of EIS UIs, namely CF, IO, and UIF, and proposed a theoretical model that relates these constructs with PE and EE. To address our main research question, we validated our theoretical model through a survey study. As shown in Table 9, our hypotheses are supported, excepting the third hypothesis (H3).

According to our findings, the IO has a weak but significant negative influence both on the EE and PE. This confirms that UIs that are considered plain and simple, and have only necessary information and controls, are perceived as clear, understandable, and easy to learn and use by the EIS users. The EIS users also believe that using systems with this type of interfaces would increase their productivity. The IO relates closely to the complexity of EIS UIs, which is known to weaken their usability [47]. Our findings confirm the effectiveness of minimalist design heuristic [18, 38] also in EIS UI design.

The CF was found to have a strong and significant influence on the EE, while its influence on the PE was found to be insignificant. When the EIS UI is adapted to the domain terminology that is commonly understood by the end users, it becomes easier for end users to learn and use the system. However, they believe that using such a system would have no influence on their productivity. In other words, the end users believe that using such systems would require less effort, but would not help them to achieve benefits in job performance. This result partially confirms the significance of familiarity on the user perception of interfaces [20].

The UIF appears as the strongest determinant of both EE and PE. The end users, who consider the UI of their EIS as well-designed and aligned with their work activities and needs, believe that their system contributes to their work performance by allowing them to do their job more quickly and thus increasing their productivity. Such systems are also considered by the end users as easy to understand and use. This signifies the importance of understanding the user requirements and their work structures, and configuring EIS accordingly. It confirms that task performance is improved when the technology is fitted to users’ needs [46]. The results also confirm the findings of studies that aim to integrate user acceptance frameworks with TTF models, which demonstrate how useful the technology can be in optimizing the task at hand [44, 69].

The research model was able to explain 68% of variance (adjusted $R^2$) in EE and 50% of variance in PE. These values are considerable when compared with the values resulted from similar studies in the literature [8, 63]. They confirm that end users’ perception of ease of use is driven largely by the three critical aspects of EIS UIs that we proposed.

Our analysis showed no significant moderation effect of gender, age, experience (of the end users with the EIS that is considered for the survey), or EIS type on the relationship between the constructs. The differences between the means of different age, gender, experience, and EIS type groups (separately for each listed factor) were also not significant for any of the model construct.

Table 9. Outcome of hypotheses testing.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Path</th>
<th>Path coefficient</th>
<th>Supported?</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>IO $\rightarrow$ PE</td>
<td>-0.24*</td>
<td>Yes</td>
<td>The less overloaded the EIS user interface is to the end user, the more useful and easier to use the EIS will be perceived by the end user.</td>
</tr>
<tr>
<td>H2</td>
<td>IO $\rightarrow$ EE</td>
<td>-0.20*</td>
<td>Yes</td>
<td>There is no evidence that familiarity of EIS user interface controls leads to an increase in end users’ productivity in work activities where they use EIS.</td>
</tr>
<tr>
<td>H3</td>
<td>CF $\rightarrow$ PE</td>
<td>0.04</td>
<td>No</td>
<td>No evidence that familiarity of EIS user interface controls leads to an increase in end users’ productivity in work activities where they use EIS.</td>
</tr>
<tr>
<td>H4</td>
<td>CF $\rightarrow$ EE</td>
<td>0.41*</td>
<td>Yes</td>
<td>The more familiar the controls of the EIS user interface are to the end user, the more useful the EIS will be perceived by the end user.</td>
</tr>
<tr>
<td>H5</td>
<td>UIF $\rightarrow$ PE</td>
<td>0.56*</td>
<td>Yes</td>
<td>The higher the perception of the EIS user interface’s level of fit is to the end users’ work activities, the more useful and easier to use the EIS will be perceived by the end user.</td>
</tr>
<tr>
<td>H6</td>
<td>UIF $\rightarrow$ EE</td>
<td>0.44*</td>
<td>Yes</td>
<td>The more familiar the IO is, the more useful and easier to use the EIS will be perceived by the end user.</td>
</tr>
</tbody>
</table>

*p < 0.01

Implications for research

This work makes two main contributions to the research. First, although technology acceptance and UTAUT have been extensively studied in the IS literature, so far the mainstream IS research has not studied UI attributes as exogenous variables to the UTAUT model [64]. To the best of our knowledge, this work is the first to extend the model with the three new exogenous mechanisms of EIS UIs that we have identified in this study. It improves the explanatory power of EIS user acceptance through UI-related new factors. These
factors provide a statistically significant explanation of the variance for EE and PE.

Second, our study contributes to the IS literature with new scale items for two key UI aspects, namely, IO and CF. While existing research on UIs typically focus on specific UI elements, structures, or presentations (e.g., navigation and menu types, search functionality, system access) [31], these new factors reflect a broader view and emphasize on abstract UI characteristics that span across UI styles and patterns. However, this also calls for future research into the specific characteristics that make an EIS UI overloaded from end user’s point of view and compare alternative design options.

**Implications for practice**

Our findings signify the role of the UIs in facilitating the success of EIS implementations and operations. As such, it has important implications for practice. Three aspects of the EIS UI have proven to show significant influence on the main predictors of the actual EIS usage. In this regard, this work advocates for a special care in designing EIS UIs. In particular, designers should put great emphasis on making the interface fit to the corresponding user task, using consistent and familiar user-domain terminology, and designing interfaces only with essential controls. The findings indicate that any improvement in the EIS UI will foster user adoption and may lead to substantial savings in time of end users and subsequently in the cost [47]. The proposed model provides a mechanism for evaluating the relative influence of design elements and characteristics, which offers important guidance to EIS designers in assessing the design choices and their impact.

Special attention should be given not only in designing and developing these systems but also during their selection and implementation. Current EIS offerings provide wide-ranging possibilities in customizing the EIS systems, including their UIs, based on unique organizational and user needs. Meticulous elicitation of these requirements becomes a critical factor for successful implementations, since haphazard customizations and extensive modifications of the standard functionalities may also hamper the usability of the system. Among the three constructs that we proposed, UIF has a relatively stronger influence on PE and EE. This further suggests the significance of understanding the needs of the end users and their tasks and adapting the EIS and its UI in accordance with these requirements. During implementation and operations of EIS, organizations should also seek for means to improve the end-user perception of EIS UI characteristics. User training and organizational support can be considered to play a critical role in influencing this perception. Hence, managers and executives should promote and give close attention to these activities during EIS implementation and operation [10].

**Limitations and future research**

Majority of the EIS end users participated in our survey are from companies operating in Czech Republic. Although we did not indicate our research objective in our invitations, there is a risk for introducing a bias in the results, as the selection of these countries were due to authors’ affiliations. This has threats for the generalizability of the results, as the responses originated only from these three countries but not from a larger population. Therefore, in order to assure higher reliability in our analysis, the future studies should consider pooling participants also from other countries. This would further strengthen the generalizability of the results.

The approach followed in operationalizing the model constructs poses a limitation to our research. In refining the scale items used to measure the constructs, we selected those that have the highest factor loadings. Although this is in line with the approach followed in previous research [41,63,68], this led to the elimination of some subcharacteristics of constructs, which in turn threatens the content validity. For example, the scale item in the third subcharacteristic of the IO construct (the perceived degree of utility of UI elements) was replaced by a scale item belonging to the first subcharacteristics that had higher factor loading. The future research should target for improving the content validity by developing and validating alternative scales to better operationalize the constructs.

Despite a significant capability of the model in explaining the variance in PE and EE, there is room for additional factors, such as the general aesthetics, vividness, interactivity, ease of navigation, standardized, and consistent use of UI elements [26]. These additional factors may also include project-, organization-, or system-related properties and conditions. Facilitating conditions, such as user training, instructions and assistance, system/organizational/management support for the system use, organizational culture, and overall system quality, are known to have an influence on the actual use and success of enterprise systems [10,28,52,55]. These factors might directly influence the user acceptance or indirectly through changing the perception on the UI characteristics. For instance, training is considered to have a significant impact on the perceived complexity of EIS [7], which may, in turn, influence the end user’s perception of UI characteristics, such as CF. Further research is required to investigate the influence of such factors and develop extensions to the model proposed in this article to better explain the drivers for end-user acceptance of enterprise systems. Future research should also address the link between the user intention and the actual EIS use and eventually the business outcomes of the EIS use.

**Conclusion**

Many organizations view their EISs as a core component of their business [59]. Notwithstanding their criticality, EIS has been criticized by the end users of their complexity and difficulty of use [60]. These factors are considered among the main barriers that prevent enterprise-wide software systems to deliver their potential benefits [50]. Developing strategies to foster system usage will be effective when organizations have a better understanding of the factors influencing the user acceptance and usage.

Our literature analysis showed a research gap on the EIS UI characteristics that can potentially influence end-user acceptance of enterprise systems. Our study fills this gap and contributes to the theoretical body of knowledge in this specific research area. We proposed three characteristics (constructs) of EIS UIs and developed multitem item scales for
two of them: IO and CF. These constructs were pretested for validity and reliability. Subsequently, the proposed model with five constructs was applied over 98 EIS end users. Overall, the results show that the EIS UI characteristics that we proposed in this study significantly influence the perceived usefulness and ease of use, which, in turn, are expected to impact the intention and actual use of these systems.

Our study provides a better understanding of the relation between latent UI properties and the perceptions of end users toward complex technology. Our analysis showed that the enterprise systems, of which the UIs are perceived to match the demands of the tasks that they aim to support, and to have only necessary controls on their UIs, are considered by the end users as useful and helpful in attaining gains in job performance. In addition, the end users believe that systems which have familiar controls on their UIs are easy to understand and use.

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References
Appendix: Survey instrument

< Demographics >

– Gender: Male/Female
– Company information
  • Company name: …
  • Country: …
– Age:
  • Less than 21
  • Between 21 and 30
  • Between 31 and 40
  • Between 41 and 50
  • Between 51 and 60
  • Over 60
– Type of the evaluated EIS:
  • ERP (enterprise resource planning)
  • CRM (customer relationship management)
  • SCM (supply chain management)
  • PLM (product lifecycle management)
  • BI (business intelligence)
– Experience with the evaluated EIS:
  • Less than 1 year
  • 1–2 years
  • 2–3 years
  • 3–4 years
  • Above 4 years
– Vendor of the evaluated EIS:
  • SAP
  • Microsoft Dynamics
  • Oracle
  • Infor
  • Salesforce
  • JDA
  • Other

< Research Model Constructs >

< Responses were indicated using 7-point Likert scale: Strongly disagree, disagree, somewhat disagree, neutral, somewhat agree, agree, strongly agree >

< Information overload (IO) (new scale) >

• My EIS contains plenty of the user interface elements that I do not need.
• I am disturbed by unnecessary user interface elements.
• My EIS user interface contains much information that I rarely use.

< Control familiarity (CF) (new scale) >

• The control of my EIS user interface seems familiar to me.
• I am familiar with the terminology used by my EIS user interface.
• Finding my way in my EIS user interface is familiar to me.

< User interface fit (UIF) (adapted from [27]) >

• User interface structure of my EIS is well designed to the work structure required for my everyday work.
• User interface of my EIS is well designed to my everyday activities.
• User interface of my EIS is well designed to my everyday work needs.

< Performance expectancy (PE) (adapted from [63]) >

• I would find my EIS useful in my job.
• Using my EIS enables me to accomplish tasks more quickly.
• Using my EIS increases my productivity.

< EE (adapted from [63]) >

• My interaction with my EIS would be clear and understandable.
• I find my EIS easy to use.
• Learning to operate my EIS is easy for me.