EXPERIMENTS IN MEASURING HETEROGENEOUS AND CREATIVE USE OF INFORMATION SYSTEMS

Workshop paper for ECIS2015 workshop on "Beyond amount of use"

Salovaara, Antti, Aalto University School of Business, Finland, antti.salovaara@aalto.fi

Abstract

Although users have differences in their IS use purposes, a simple frequency of use continues to be the most often used measure of IS use. However, this measure is insensitive to the different variants of system use, such as their creativity and heterogeneity. To support more sensitized research on information systems (IS) use, this paper presents empirical experiments that have aimed at developing measures for heterogeneous use (IS use for multiple purposes) and creative use (inventions of using IS for purposes previously unknown for the user). The paper presents a three-step approach required for their measurement, formulas for their calculation, overviews of the data that the methods have produced, and preliminary evaluations of the measures' suitability for their tasks.

Keywords: Heterogeneous use, Creative use, Information systems use.

1 Introduction

One of the peculiarities of adoption and diffusion research is its widespread commitment to using total frequency of use as the dependent variable (DV) in practically all of the information system (IS) adoption and continued use models. Models that use this metric include, for instance, the widely recognized technology acceptance (Davis, 1989; Davis et al., 1989), UTAUT (Venkatesh et al., 2003, 2012) models as well as frameworks for predicting continued use based on habits (Limayem et al., 2007), expectation and confirmation (Bhattacherjee, 2001) as well as attitudes (Karahanna et al., 1999).

The virtue of using frequency as a measure of IS use lies in its simplicity and comparability across models and contexts. Measuring frequency is straightforward as a self-report variable or through automatized logging. Also, it can be readily put into a scalar form, which makes it suitable for practically all types of predictive quantitative models. For researchers, adopting frequency of use as a model's DV allows for added value through comparability against other similar models.

However, in light of empirical evidence, measuring use through a frequency-based metric is problematic. Frequency of use as a measure has several implied assumptions that may not hold in many contexts. First, it assumes that all use is of equal importance, that is, that all users will use the same IS in an equally efficient manner. The second assumption is that all types of use can be measured as a cumulative sum. Systems can be however used for many different purposes (Salovaara et al., 2011, 2013). These purposes may be related to tasks and situations that occur at different frequencies. Microsoft Excel, for instance, is commonly be used both for chart-making, manipulation of long lists, and simple calculations (Salovaara et al., 2013). A total frequency of use is a measure in which uses like these are simplistically added together. In short, in many cases, a simple frequency of use may not represent the kind of use that it is intended to address.

The unsuitability of frequency of use as a DV is evident in knowledge work contexts. In knowledge work, the most important tasks are those that require non-routinized problem solving (e.g., Blackler. 1995). Such tasks may occur at unexpected intervals, introduction a lot of undesired temporal fluctuation into an IS's frequency of use. In addition, it is not the frequency that matters but whether the tool contributes to solving problems. Therefore, all types of use should not be counted as being equal and they should be possibly measured on different time scales.

Contrary to the ideology presented in many IS science papers, system's use for unexpected purposes may be a positive indicator of IS success. The traditional rationale has been that ISs are implemented and adopted in organizations with a goal of improving efficiency in predefined organizational activities. In this thinking, systems are tailored to support specific activities, and using them according to this "spirit" is considered as providing the best "bang for the buck". Unexpected uses, on the other hand, are seen as suboptimal or even harmful to organizations.

It is however possible to argue from an opposite viewpoint, stating that if an IS is used to serve multiple purposes of use, it supports a larger scope of work activities than a system that is being used for one purpose only. Using IS in unexpected ways can be considered as particularly beneficial: it provides an opportunity for organization-wide improvement of work practices.

This paper presents empirical explorations on two ways in which more heterogeneous IS uses could be measured. The first of the measures addresses *heterogeneous use* by which I mean use of an IS for multiple purposes (i.e., for different goals in different tasks). The other measure addresses *creative use*, which I define as invention of using IS for purposes previously unknown for the user. In both of the cases, the definitions are oriented to individuals and their tasks.

2 The three-step research process

In the studies on IS use that have addressed heterogeneous or creative use, the primary method has been to ask the respondents self-report assessments of their creative use. This self-report assessment of creativity has been applied both in an early study by Price and Ridgway (1983) as well as in more re-

cent studies by Nambisan et al., (2000), Ahuja and Thatcher (2005), Mills and Chin (2007), Bagayogo et al. (2014), or Hsieh, Wang, and their colleagues (Hsieh & Wang, 2007; Wang et al., 2008). In most cases the elicitation methods has been Likert-style statements such as "1 have used this ERP system in novel ways to help my work." (Wang et al., 2008). A different approach was presented in Sun's study (2012) where he first asked respondents to "report one incident wherein they changed their use of MS Office features" (p. 465). The subsequent questionnaire items were asked in context of this respondent-provided story. This made the questions less abstract if compared to the other above-listed empirical studies.

However, neither Sun (2012) nor the other above-cited papers have inquired about actual heterogeneous or creative uses, detailing what these uses might be. Although some of the respondents of Sun's study may have provided told stories about heterogeneous or creative uses, the format of the question did not ensure that this would apply to all the responses. By not explicating what the heterogeneous or creative IS uses might mean for each respondent, the studies published this far have not allowed for validation of their answers: it is not possible to verify that the self-report response reflect the true heterogeneity or creativity, or these phenomena on a commensurable level of abstraction.

My attempt is to develop more transparent measures for heterogeneous and creative IS. Instead of only relying on the respondents' self-assessments, I aim for explicating the different creative and heterogeneous uses. By better operationalizing what heterogeneous or creative IS uses are, it will be possible to better understand and examine these elusive concepts.

To this end, I maintain that in quantitative studies on IS use, the measures of creative and heterogeneous IS use must be quantifiable and comparable across respondents. To ensure this, the questionnaire items must be presented in the same way for each participant, in a closed-ended forced-choice format. Only this ensures that all answers are complete and comparable. However, this questionnaire item format limits the set of alternative and seems to run against the idea of heterogeneity and creativity that carry the ideas of unexpectedness and impossibility to enumerate the reality comprehensively. The set of different alternatives to be presented in a questionnaire seems endless, since any feature or a feature set of an IS may be used to serve different ends in different situations by different users.

Although the respondents could be simply asked to list all of their ways of using a given IS in an open-ended manner, but this would not lead to a quantifiable reliable measure. With high likelihood, some respondents would omit listing uses that others would list. The answers could also describe IS use on different levels of abstraction. Such data would not be suitable for statistical analysis. Thus, to ensure comparability of responses across respondents, questionnaires need to consist of closed-form forced-choice questions. This ensures that all respondents will have a common ground based on which data can be analysed and compared.

The general approach that I suggest is to measure heterogeneity and creativity in a three-step process consisting of *observation, cataloguing and inquiring*. In the first step, researchers observe IS use in order to understand the ways in which it may be used. This may require ethnographic work, interviews, or analyses of datasets of technology use. In some cases, when the technology and its context of use are familiar to the researchers, the observations can be completed with researchers' personal knowledge about the uses of the IS.

The knowledge gained in the first step is used in the second step, in which a representative catalogue of possible uses is created. If the research goal is to study heterogeneous IS use, the list will contain at least the most common purposes of use on a level of abstraction that is suitable for the purposes of the study. In the case of researching creative IS use, the list consists of uses that many users would consider as unexpected and uncommon but nonetheless useful.

This proposed approach does not by any means attempt to catalogue all the possible purposes of use that represent heterogeneity or creativity. It suffices that the uses included in the questionnaire are as a whole sufficiently representative of the construct that is being measured. Therefore, the requirement for measuring heterogeneity is only that the questionnaire asks about several different and well-chosen purposes of use. A set of six different purposes of use, for instance, may already cover 95% of the

ways in which a user population uses the system as a whole. Adding a seventh purpose of use would then not improve the measure of heterogeneity considerably. Similarly, if the catalogue of uses contains six unquestionably creative uses of an IS, it then already represents creative use to some extent. Adding a seventh creative use will make the measure significantly more representative only if it introduces a new dimension of creativity to the measure; if it only adds one rather rare creative use that is not qualitatively different than the other six, the catalogue will not be considerably improved by that addition. Instead, the questionnaires only will become longer.

Finally, in the third step, IS users are inquired about each of the uses catalogued. The following two sections will provide empirical examples of this approach.

3 Measuring heterogeneous use

In a recent study (Salovaara et al., 2013), we were interested in exploring the amount of heterogeneity in students' Microsoft Excel. Although the actual goal of that study was to show that *PU–U* correlations are dependent on the purposes of use that are being considered, the following presentation will focus on the work related to the measurement of heterogeneous IS use.

Because our team was already familiar with Excel and had a good understanding of its possible uses, we omitted the observation stage from the three-step approach. We created a catalogue of different plausible and supposedly frequent purposes of use, concluding with a list of the following six: making charts, calculation in tables, note-taking, management of long table-based data, complex calculations, and simple calculations (for more detailed descriptions, see Salovaara et al., 2013).

In the third part of our three-step approach, we inquired about the frequencies of use for each of the six purposes. The measure was a self-report estimation of the times that the respondent had used Excel during the past 7 days. We accepted also decimal values, especially between 0 and 1, to account for cases where the use was less frequent than once a week. If a respondent used Excel for note-taking, for instance, only once in 4 weeks, she could provide 0.25 as an answer.

3.1 Results

Figure 1 presents a result that proved our hypothesis that Excel's heterogeneous use is widespread among first-year students. In the figure, students (N = 52) are ordered by the percentage of their most common use purpose out of each one's total use. The right extreme (marked with A) of the chart presents the most homogeneous of all the users: those whose most common purpose of use (whatever it is of the six alternatives) amounts to 100% of their total use, meaning that they use Excel for one purpose only. These single-purpose users accounted fro as few as approximately 10% of all the respondents. In the most heterogeneous extreme (marked with B), Excel was used for its most common purpose only 20% of the time. Finally, a median user (at 50% mark, marked with C) used Excel for more than 3 different purposes. The three most common purposes account for approximately 90% of this respondent's total use.

Our study did not require us to develop a measure of heterogeneous use for each user, but we will explore it here. In our data, we had a set of U values for every user, each U representing a use frequency of a different purpose of use. Transforming each user's Us into percentages summing to 100% (a step that had been already carried out in preparation of Figure 1), heterogeneous users consisted of those whose percentages for different purposes were close to equal, meaning that such users made use of Excel for many purposes equally frequently. Similarly, users with a very homogeneous use pattern had 100% of use assigned to one purpose of use and zero for the others. From such percentage sets, a measure of heterogeneous use can be considered as a negation of the variance of the percentages: a person with the same frequency of use for all the six purposes of use (i.e., who has high heterogeneity in use) will have a variance of $\mathrm{StDev}(^1/_6, ^1/_6, \ldots, ^1/_6) = 0$ for six uses. A candidate formula for calculating a person's extent of heterogeneous use—h—can be then obtained by inverting this value, such as by subtracting it from one. For n different purposes of use, h can be then defined as follows:

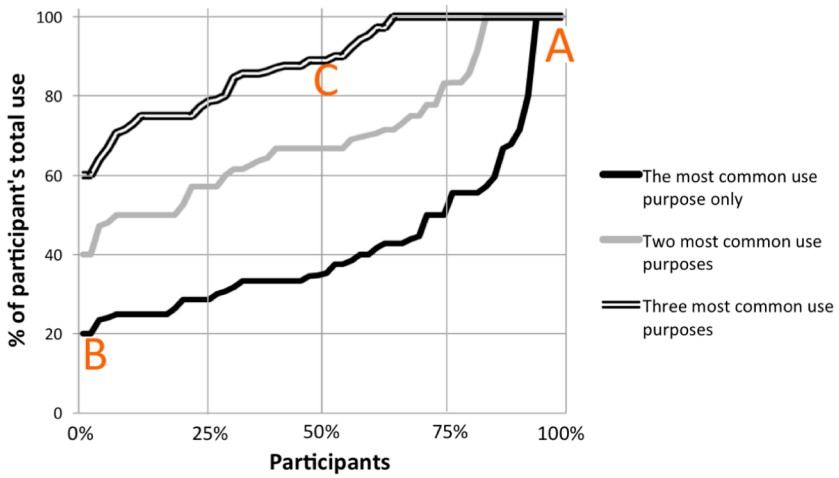

Figure 1. *The extents that one, two and three most common uses constituted of the total Excel use for each user.*

$$h = \frac{1 - \mathrm{StDev}\left(p(U_1),\ldots,p(U_n)\right) - (1-k)}{k} = \frac{k - \mathrm{StDev}\left(p(U_1),\ldots,p(U_n)\right)}{k} \quad \text{where} \quad k = \mathrm{StDev}(1,\underbrace{0,\ldots,0}_{n-1 \text{ times}})$$

I have used constant k in the formula to normalize the values into a range between 0 and 1. Also, I have used standard deviation (StDev) instead of variance, because it provides a distribution that is closer to normal. Figure 2 shows this distribution for the 52 users in our data.

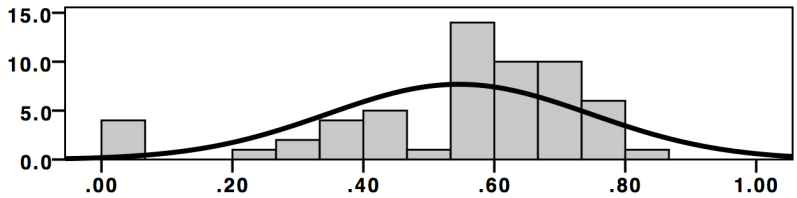

Figure 2. *Histogram depicting distribution of heterogeneity of use (h) in the sample.*

In this distribution, the median user has $h = .59$. This value will result, approximately, if the user has exactly three uses for Excel, each with an equal amount. This interpretation corresponds closely to the observation C in Figure 1.

3.2 Evaluation

Does the formula for h suffice as a measure of heterogeneous use? Although the distribution resembles normal distribution, Shapiro-Wilk's does not support this interpretation ($W = .865$; $p < .001$). Therefore, strictly speaking, using h in an IS use model leads to a requirement of using non-parametric methods. This is a hindrance if the intention is to develop regression or structural equation models.

On the other hand, the formula for h offers a tool for making qualitative interpretations of a large array of use frequency data that would otherwise need to be merely plotted (as in Figure 1) and left without further analysis. Also, h can always be calculated for any catalogue that contains at least two alternatives. This increases the convenience of applying it in analyses. However, ascertaining the validity of h as a measure of heterogeneous use would deserve a dedicated research effort. I am currently gathering two other datasets on Excel use that may help in ascertaining the validity of this measure.

4 Measuring creative use

In another study, we measured creative use in a study of uncommon uses of digital cameras (Salovaara et al., 2011). Based on observations and our own familiarity with digital cameras, we shortcut the observation step also in this study, and made a catalogue of eight possible creative uses in the second step of our three-step research process: mirror, map, note-taking device, scanner, memory storage, lamp, instruction device, and periscope (for more details, see the paper). We then devised a questionnaire to inquire about such uses in a survey in the third step of our process.

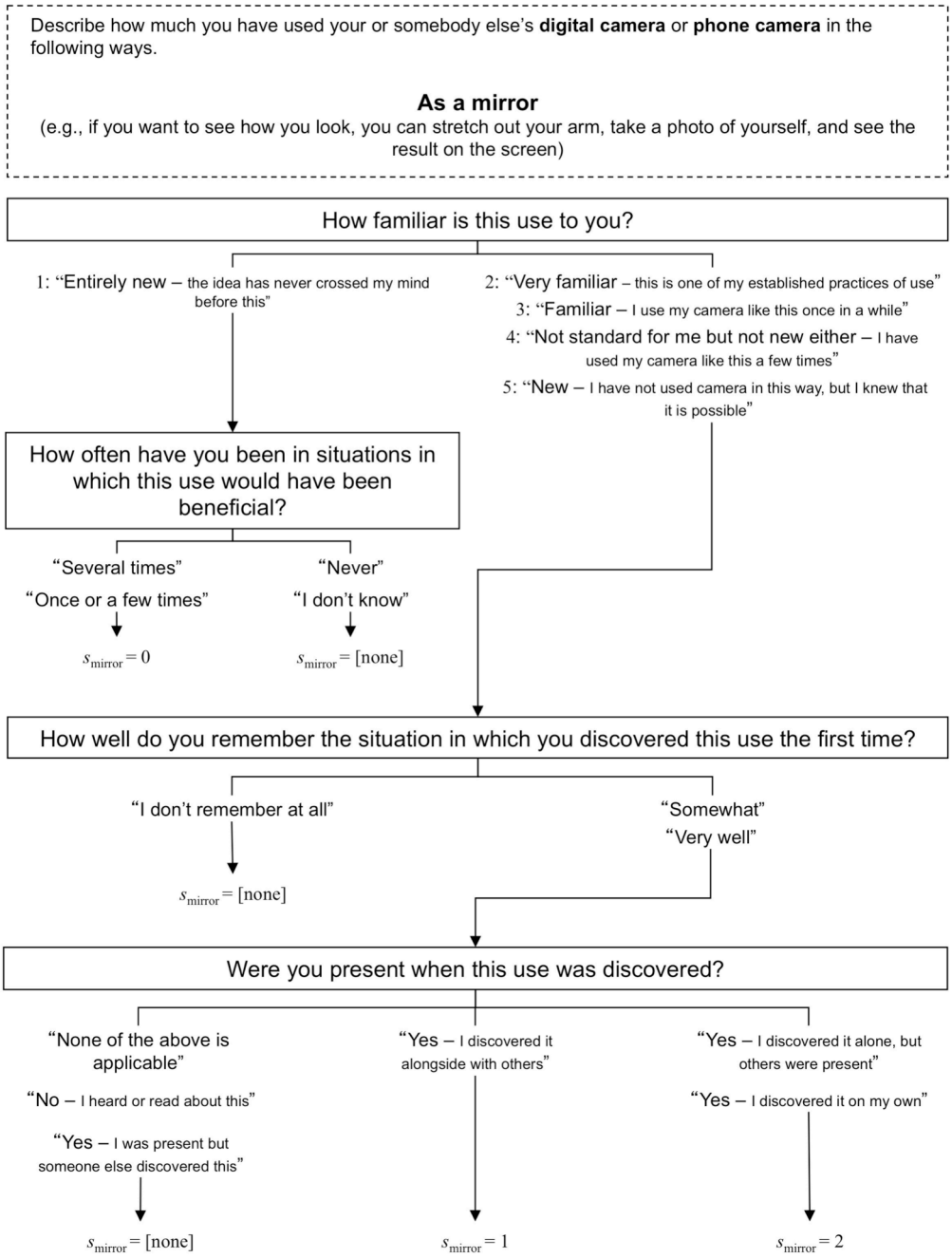

Figure 3. A tree-structured questionnaire used for assigning a score s for creative use of digital cameras.

In order to ensure that the catalogue contained creative uses specifically, we could not only ask about frequencies of use in the same way as we did in the Excel study. Namely, we also had to find out how each of the respondents had learned each use. Only those users could be considered creative who had discovered many of the uses themselves, without having been helped by others. We also had to take into account the possibility that the users did not anymore remember whether they had received help from others. Control questions were needed to exclude such unanalyzable cases from the data.

As an answer to these problems, we developed tree-structured question sets for each purpose of use (see Figure 3 for an example addressing a digital camera's use as a mirror). As indicated by the arrows in the figure, we asked the follow-up questions only in the condition wherein the respondent was able to provide an answer to it, given the previous answer. In the actual web-based questionnaire, we showed the different parts of the tree in sequence, equipped with an interactive logic that kept only those questions active that were logically possible in light of earlier responses.

To measure creative use, we ranked the possible answer paths and gave them $s = 0$, 1, or 2 as a creativity score (see the leaf nodes in Figure 3). As the marks with "[none]" in Figure 3 also show, some answers could not be assigned any score due to respondents' poor recall or a lack of need for the given use. The overall score of creative use—*c*—for each respondent was calculated as $c = {}^{1}/_{n}$ sum(s_i), where s_i was the score for creative use *i* and *n* was the number of scores used in the sum.

4.1 Results

A histogram of responses (N = 2,379) is presented in Figure 4. The bimodal distribution with modes in the scale's extremes suggests that most users could be classified as either persons who do not discover creative uses by themselves (i.e., having c ≈ 0) but may learn about them from others or people who discover all of the creative uses alone (i.e., with c ≈ 2). On average, of the eight creative uses in our catalogue, creative uses had been at least tried out by 48% of the participants in our sample.

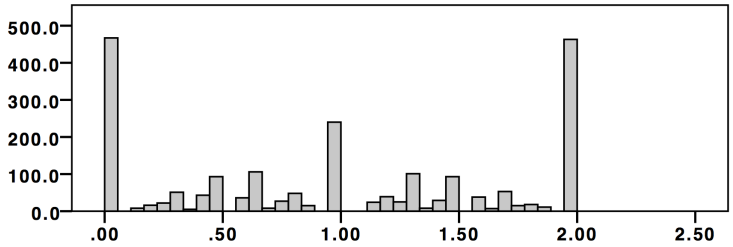

Figure 4. Histogram depicting distribution of creative use (c) in the sample.

4.2 Evaluation

Although taking an average over a set of measures should increase the resulting composite measure's normality, in this case the distribution of *c* was far from normal. In our study (Salovaara et al., 2011), this characteristic forced us to adopt non-parametric methods for our analyses where we search for antecedent factors of creative use.

Although deviance from normal distribution is a problem for many statistical analyses, it may also reflect reality: a possibility must be maintained that users really can be divided into two populations with respect to their propensity of discovering creative uses for cameras. Before this conclusion is drawn, however, it is important to notice that the calculation of average in the formula for *c* is sensitive to the number of uses that could be successfully scored. Thus, if a respondent remembered the event of discovery for only one of the creative uses, the score for this use could become the only value from which *c* for this person's could be calculated. The validity of *c* is therefore highly dependent on the number of scoreable uses and therefore on, for instance, respondents' recall of their discoveries of creative uses.

Conceptually, what is measured with *c* is not the full range of creative IS uses. This measurement cannot capture those creative situations of which the researchers themselves have not been aware of. Another problem is to demarcate rare but non-creative uses from those uses that really have required an insight from the user. Although this demarcation is crucial to the validity of the measure, in the study presented above, we could verify it only retrospectively, relying on respondents' memory of events that could have occurred several years in the past. This resulted in a lot of missing data—answers that we had to code with "[none]" and omit from our analysis.

To better ensure that only creative discoveries of IS use are included in the analysis, one needs more sophisticated methods than cross-sectional questionnaires. One possible method—however invalid—would be to adopt a longitudinal research design where the first questionnaire would inquire about the catalogued assumedly creative uses. The answers from each respondent would establish a baseline for which later answers would be compared to. The second questionnaire would then repeat the inquiry about the catalogued creative uses. However, the problems with this research design would be twofold. First, all the new uses would not be necessarily discovered by the respondent alone, but could have been learnt from others. The comparison would need to be controlled by the nature of discovery. A remedy of this problem would require asking about the situation in which the discovery was made, in order to validate its insightfulness. This would however again depend on the respondents' memory and would not be much better than a cross-sectional research design. Second, and more importantly, the first questionnaire's content would bias the answers of the second one by subjecting the respondents to ideas of possible creative uses. This would positively affect their ability to notice opportunities for starting applying such uses. It would be, however, invalid to consider an increase in the creative uses as a symptom of a respondent's creativity. Instead it would be a symptom of learning from the researchers.

Longitudinal questionnaire-based research design is therefore hardly suitable for studying creative IS use. However, such a measurement can be suitable for studying uncreative heterogeneous IS uses where the aspect of insightful discovery is not crucial. The subjecting the respondents to possible uses in the first questionnaire will bias the answers of the second questionnaire much less, because the respondents are already familiar with such uses.

Returning back to the question of validly measuring creative IS use, a better research design would be to carry out a controlled lab-like experiment. By asking the participants carry out tasks that they originally cannot solve but which they manage to do after a suitable intervention, such as a deliberate hint from an experimenter, one can be sure that no other factors have caused the discovery of a creative use. I am in a process of preparing such an experiment, but pilot studies have shown that the hints need fine-tuning before the actual study can be started.

5 Discussion

This paper has presented two aspects of IS use that are difficult to measure: heterogeneous use and creative use. Developing measures for such features remains an unfinished and ongoing work. While the results presented in this paper give some reason for optimism, there are also weaknesses that need to be addressed. Both of the metrics are sensitive to the size and the content of the catalogues of uses. If heterogeneity is measured using a large catalogue, many respondents will report zero frequencies of use for many purposes, which decreases their *h* measures. The same applies for the measurement of creative use. As a result, the measurements cannot be compared across different studies straightforwardly. In addition, when measuring *c* in the manner presented in this paper, the effect of respondents' poor recall of the events leads easily to a significant percentage of missing data. Also, strictly speaking, currently both of the measures can be used in non-parametric analyses only.

The future efforts in the measures' further development are in their more dedicated validation. The sensitivity to the catalogue size, catalogue content, recall effects (in the case of *c*) are areas where the methods for measuring *h* and *c* should be improved. In addition, the measures would require triangulation with other methods so as to make sure that they are measuring the intended aspects of IS use.

References

Ahuja, M. K. and Thatcher, J. B. 2005. "Moving Beyond Intentions and Toward the Theory of Trying: Effects of Work Environment and Gender on Post-Adoption Information Technology Use," *MIS Quarterly* (29:3), pp. 427–459.

Bagayogo, F. F., Lapointe, L., and Basselier, G. 2014. "Enhanced Use of IT: A New Perspective on Post-Adoption," *Journal of the Association for Information Systems* (15:7), pp. 361–387.

Bhattacherjee, A. 2001. "Understanding Information Systems Continuance: An Expectation-Confirmation Model," *MIS Quarterly* (25:3), pp. 351–370.

Blackler, F. 1995. "Knowledge, Knowledge Work and Organizations: An Overview and Interpretation," *Organization Studies* (16:6), pp. 1021–1046.

Davis, F. D. 1989. "Perceived Usefulness, Perceived Ease of User, and User Acceptance of Information Technology," *MIS Quarterly* (13:3), pp. 319–340.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. 1989. "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science* (35:8), pp. 982–1003.

Hsieh, J. J. P.-A. and Wang, W. 2007. "Explaining Employees' Extended Use of Complex Information Systems," *European Journal of Information Systems* (16:3), pp. 216–227.

Karahanna, E., Straub, Jr., D. W., and Chervany, N. L. 1999. "Information Technology Adoption across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs," *MIS Quarterly* (23:2), pp. 183–213.

Limayem, M., Hirt, S. G., and Cheung, C. M. K. 2007. "How Habit Limits the Predictive Power of Intention: The Case of Information Systems Continuance," *MIS Quarterly* (31:4), pp. 705–737.

Mills, A. and Chin, W. 2007. "Conceptualizing Creative Use: An Examination of the Construct and its Determinants," in *Proceedings of Americas Conference on Information Systems (AMCIS 2007).*

Nambisan, S., Agarwal, R., and Tanniru, M. 1999. "Organizational Mechanisms for Enhancing User Innovation in Information Technology," *MIS Quarterly* (23:5), pp. 365–395.

Price, L. L. and Ridgway, N. M. 1983. "Development of a Scale to Measure Use Innovativeness," in *Advances in Consumer Research,* R. P. Bagozzi and A. M. Tybout (eds.), Ann Arbor, MI: Association for Consumer Research, pp. 679–684.

Salovaara, A., Helfenstein, S., and Oulasvirta, A. 2011. "Everyday Appropriations of Information Technology: A Study of Creative Uses of Digital Cameras," *Journal of the Association for Information Science and Technology* (62:12), pp. 2347–2363.

Salovaara, A., Öörni, A., and Sokura, B. 2013. "Heterogeneous Use for Multiple Purposes: A Point of Concern to IS Use Models' Validity," in *Proceedings of the Thirty Fourth International Conference on Information Systems (ICIS 2013),* F. Pennarola, J. Becker, R. Baskerville, and M. Chau (eds.).

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. 2003. "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly* (27:3), pp. 425–478.

Venkatesh, V., Thong, J. Y. L., and Xu, X. 2012. "Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology," *MIS Quarterly* (36:1), pp. 157–178.

Wang, W., Hsieh, J. J. P.-A., Butler, J. E., and Hsu, S.-H. 2008. "Innovate with Complex Information Technologies: A Theoretical Model and Empirical Investigation," *Journal of Computer Information Systems* (49:1), pp. 27–36.