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Is the LITE version of the usability metric for user experience (UMUX-LITE) a reliable tool to support rapid assessment of new healthcare technology?

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ABSTRACT

Objective: To ascertain the reliability of a standardised, short-scale measure of satisfaction in the use of new healthcare technology i.e., the LITE version of the usability metric for user experience (UMUX-LITE). Whilst previous studies have demonstrated the reliability of UMUX-LITE, and its relationship with measures of likelihood to recommend a product, such as the Net Promoter Score (NPS) in other sectors no such testing has been undertaken with healthcare technology.

Materials and methods: Six point-of-care products at different stages of development were assessed by 120 healthcare professionals. UMUX-LITE was used to gather their satisfaction in use, and NPS to declare their intention to promote the product. Inferential statistics were used to: i) ascertain the reliability of UMUX-LITE, and ii) assess the relationship between UMUX-LITE and NPS at different stages of products development.

Results: UMUX-LITE showed an acceptable reliability ($\alpha = 0.7$) and a strong positive correlation with NPS ($r = 0.455$, $p < .001$). This is similar to findings in other fields of application. The level of product development did not affect the UMUX-LITE scores, while the stage of development was a significant predictor ($R^2 = 0.49$) of the intention to promote.

Discussion and conclusion: Practitioners may apply UMUX-LITE alone, or in combination with the NPS, to complement interview and 'homemade' scales to investigate the quality of new products at different stages of development. This shortened scale is appropriate for use in the context of healthcare in which busy professionals have a minimal amount of time to support innovation.

1. Introduction

Experts should control three key dimensions: efficiency, effectiveness and satisfaction in specific context of use during usability testing (International Organization for Standardization, 1998, 2015). Usability is usually evaluated by recording the performance of the end-users on predefined tasks to measure interactive errors, task achievement and time of performance and to estimate efficiency and effectiveness of new products. Satisfaction is considered the subjective dimension of the quality of interaction with a product (Flavián et al., 2006; Han et al., 2001) and it is evaluated by validated questionnaires during usability testing, or after a period of use of the product i.e., post-use satisfaction or satisfaction in use.

This well-studied dimension (Borsci et al., 2015; Dillon, 2001; Frøkjær et al., 2000; Ives et al., 1983; Lindgaard and Dudek, 2002) is affected by the context of use and by people's performance during the interaction e.g., end-users satisfaction drops when they experience issues when they are interacting with a product that has low levels of efficiency and effectiveness. All the three dimensions of usability are important to ensure quality of products and services and to improve the experience of healthcare systems (Russ et al., 2013). Moreover, satisfaction tools could be used as proxies for estimating the product usability at early stages of design. This may be helpful when there is very limited time and/or opportunity for gathering data about effectiveness and efficiency to inform rapid redesign. This is therefore a quick and low cost way to monitor the quality of interaction and to inform the need for a redesign (before subsequent thorough usability testing.) This may occur, for example.

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(i) in rapid prototyping, where designers implement changes on the design and function of an already tested technology.
(ii) during the deployment in the field of a new product when multiple people may interact, in different context of use, with the technology, as is often the case within healthcare.

Many usability questionnaires are available to measure satisfaction (Borsci et al., 2015). Longer evaluation scales are usually applied to perform summative evaluation (e.g., Software Usability Measurement Inventory (Kirakowski, 1996), and Questionnaire for User Interface Satisfaction (Tullis and Stetson, 2004). Shorter (and free to use) scales are available to rapidly assess the product during the development or to assess the stakeholders' reaction e.g., System Usability Scale (SUS, Brooke, 1996; 2013), Usability Metric For User Experience (UMUX, Finstad, 2010), and its reduced version UMUX-LITE (Borsci et al., 2015; Lewis et al., 2013).

Satisfaction measures are strongly related to other important dimensions of quality, such as perceived usefulness and acceptance (Holden and Karsh, 2010; Karsh et al., 2010; Or and Karsh, 2009; Or et al., 2011) therefore, the ability to monitor end-user satisfaction of products and services throughout the different stages of the design process with a minimal effort exists.

Usability studies in healthcare usually designed to measure task time and errors i.e. efficiency and effectiveness yet little attention is paid to the measure of satisfaction. This is despite the availability of well-established tools for measuring user satisfaction being applied outside of healthcare (Borsci et al., 2009, 2015; Brooke, 1996, 2013) For instance, the SUS is widely used in health care to measure satisfaction with new devices (Agnisarman et al., 2017; Klaassen et al., 2016), but we are unaware of any systematic analysis of the properties of such a tool in the health technology field (Borsci et al., 2016). Moreover, a specific issue seems to affect this field when it comes to measuring satisfaction. Healthcare professionals have a well establish tendency to apply 'homemade' scales (Batbaatar et al., 2017; Hall and Dornan, 1988) for the assessment of satisfaction. This has two main consequences (Hall and Dornan, 1988; Peersman et al., 2002). First, untested scales tend to provide more positive results compared to standardised tools (i.e., they inflate satisfaction on average by 10%, see: Hall and Dornan, 1988), and second this undermines replicability and comparability of data (Batbaatar et al., 2017; Peersman et al., 2002).

The use of scales without a proper validation may have adverse consequences for the design of devices, such as diagnostic point-of-care tools (POCT). Such tools are often portable devices, with different levels of digitalisation, developed to perform rapid diagnostic analysis close to patients in clinical or in home settings. Validated tools to measure satisfaction are required, perhaps to go alongside qualitative items, thus offering researchers the possibility of gathering both fit-for-purpose perspectives and a valid and comparable set of data about end-user satisfaction with a product. The analysis of the properties of standardised tools for satisfaction assessment in health care settings and the diffusion of these tools, further enables human factors experts to measure and identify strategies to improve the overall quality of the healthcare systems (Karsh et al., 2010).

This paper discusses and ascertains the reliability of a short questionnaire, validated in other domains (UMUX-LITE, see: Lewis et al., 2013), in the field of health technology development.

1.1. The LITE version of the usability metrics for user experience

The original scale of UMUX was proposed by Finstad (2010), and the LITE version was developed and validated by Lewis and colleagues in 2013 (Lewis et al., 2013). This relatively new short scale is composed of only two positively-worded questions on a 7 point Likert-scale, from 1 (strongly disagree) to 7 (strongly agree) (Lewis et al., 2013) formulated as follows: i) [This system's] capabilities meet my requirements; ii) [This system] is easy to use. UMUX-LITE results may span from 0 to 100 and the overall scale may be benchmarked with a regression formula (Lewis et al., 2013) to the results of the most applied scales of satisfaction in the usability field, the SUS (Bangor et al., 2008a; Borsci et al., 2009; Brooke, 2013; Orfanou et al., 2015). In this sense, the UMUX-LITE is proven to be equivalent to SUS in terms of overall score of satisfaction. Nevertheless, SUS has the advantage of providing much more than only an overall score as it also gives indications about the weaknesses and strengths of a product (Bangor et al., 2008b; McLellan et al., 2012). UMUX-LITE only provides a single score but it minimises the effort of respondents, and this becomes important when there are significant time pressures for responders and designers. UMUX-LITE also has the following advantages: i) it can be easily incorporated before or after a qualitative survey without increasing the effort of respondents, and providing useful, comparable and reliable data to practitioners (Lewis et al., 2013); ii) being equivalent to SUS the overall score of UMUX-LITE can be benchmarked by using the Curved Grading Scales (CGS) proposed by Sauro and Lewis (2016) to interpret and generalised the results of SUS.

Multiple studies in different (non-healthcare) fields have tested and confirmed the psychometric properties of UMUX-LITE (Berkman and Karahoca, 2016; Borsci et al., 2015; Lewis et al., 2013), nevertheless we are not aware of studies that have used UMUX-LITE to assess healthcare products, such as POCT.

2. Aim of the study

This study empirically tests the application of UMUX-LITE to assess satisfaction when using POCT prototypes and thus enable its use in medical settings. We decided to test the UMUX-LITE because it is i) relatively new, ii) short and iii) equivalent to the SUS, in terms of outcomes. These aspects make the UMUX-LITE a perfect candidate to rapidly check products at early stages of design and after each iteration of redesign.

Based on the current literature on UMUX-LITE (Berkman and Karahoca, 2016; Borsci et al., 2015; Lewis et al., 2013), our expectations were that:

(i) UMUX-LITE will have an acceptable level of reliability (Cronbach's $\alpha \geq 0.7$) when applied to assess user satisfaction with POCTs. Previous (non-healthcare) studies indicate a level of reliability of UMUX-LITE ranging from 0.77 to 0.8 (Berkman and Karahoca, 2016; Borsci et al., 2015; Lewis et al., 2013).
(ii) UMUX-LITE will have a significant relationship with the user's likelihood to recommend a product. Evidence of such a relationship – specifically a positive correlation – can be found in research from other (non-healthcare) domains (Borsci et al., 2015; Lewis et al., 2013; Sauro and Lewis, 2016). The measure of likelihood to recommend, and in a particular the Net Promoter Score (NPS, Reichheld, 2003; Reichheld and Covey, 2006) is known to correlate with satisfaction scales and some indications suggest that satisfaction could explain up to 30% of the end-users likelihood to promote (Sauro and Lewis, 2016). Thus, identifying a correlation among UMUX-LITE and NPS would suggest that the first tool maintains its properties when it is applied to assess healthcare technology.

3. Methods

Qualitative and quantitative methods, including interview, demonstration and simulation of use were applied to evaluate six types of products at different Technology Readiness Level (TRL, see: Magnaye et al., 2010; Mankins, 1995, 2009). TRLs represent different phases of product development. From TRL 1 (scientific research translated into applied research and development) to TRL 9 (Technology system in its final form and in full commercial deployment). Usability assessment is usually performed when a concept needs to be turned into a prototype (from TRL 4 to TRL 6), or when in its final form (TRL 8 and 9).

In this paper, we will indicate the main clinical purpose of each POCT, but, for reasons of industrial-research confidentiality, we cannot identify each product. All products used for the analysis were under development and the aim of this article is not to assess the POCTs, but to explore the psychometrics' properties of UMUX-LITE as a tool to measure the satisfaction of POCT at different stages of development. Whilst the characteristics of each POCT are important for the general purposes of the usability evaluation, these are not relevant for the purposes of this research.

Each product served a specific clinical pathway and healthcare professionals were recruited who had diagnostic expertise in each of these pathways. A total of n = 120 participants were recruited (through email invitations) to evaluate different POCTs. The data gathering took place from January 2016 to February 2017. Healthcare professionals were invited from within the clinical network of NIHR Diagnostic Evidence Cooperative (DEC) of Imperial College of London, UK.

Approval for interviews was obtained (Service Evaluation approval REF: SE127 and SE 165). After a demonstration of the product, participants were asked to interact with one of the products according to a predefined scenario of use. Following this, participants were asked to fill in the UMUX-LITE and a questionnaire to assess their likelihood to recommend. For this study, we used decide to use the NPS (Reichheld, 2003; Reichheld and Covey, 2006), a commonly applied measure of likelihood to recommend. This single item tool, with a scale from 1 to 10, aims to estimate the number of people who are willing to promote, detract or be neutral toward a service or a technology. NPS is already applied in the healthcare field to assess patient experience toward clinical service and treatments (Hamilton et al., 2014; Seto et al., 2012; Sizmur et al., 2015) or to assess new healthcare products (Seto et al., 2012; Singh et al., 2017).

Demographic information, UMXU-LITE and NPS data, and the TRL levels of the six POCT were analysed using descriptive and inferential statistics, and reliability analyses were undertaken using IBM®SPSS® statistics version 22.0. We also performed a 2000 sample bootstrap simulation of the UMUX-LITE Cronbach's α (Cha et al., 2007; Okazaki et al., 2012).

4. Results

4.1. Participants

A total of n = 120 healthcare professionals (76 Females; Average Age: 35.6, SD: 8.7; Years of Experience with diagnostics for the specific clinical pathway: 6.9, SD: 5.8) were involved in the evaluation of the POCT – four respondents were excluded because of errors made in questionnaire completion (see Table 1).

Table 1
Types of products (POCT) and information about the participants.

Type of POCT	TRL	N. of participants	Average Age	Experience (years) with diagnostics for the specific clinical pathway
1) Paper test for enzymatic analysis	4/5	44	34.5	7.8
2) High tech blood test	6/7	10	35.4	8.1
3) High tech breath test	8/9	18	34.4	5.9
4) Low tech breath test	8/9	16	34.7	6.4
5) Experimental breath test	6/7	17	35.6	6.9
6) High tech test for acute coronary syndrome	8/9	11	39	6.1

4.2. UMUX-LITE reliability

Wilcox signed Rank test showed no difference within groups in terms of age and years of expertise of participants. A linear regression analysis revealed no significant relationship between perceived usability (UMUX-LITE) and the development stage (TRL) of the six POCTs. Table 2 details participants' satisfaction ranging from 60.3% (POCT 6) to 76.5% (POCT 2). We reported the results by using the regression formula proposed by Lewis et al. (2013) to normalise the UMUX-LITE scores on the basis of SUS. UMUX-LITE scores were graded by using the CGS (Sauro and Lewis, 2016) from F to A+. CGS defines a range of usability grades from F (absolutely unsatisfactory) to A+ (absolutely satisfactory), as follows: Grade F (0–51.7); Grade D (51.8–62.6); Grade C– (62.7–64.9); Grade C (65.0–71.0); Grade C+ (71.1–72.5); Grade B– (72.6–74.0); Grade B (74.1–77.1); Grade B+ (77.2–78.8); Grade A– (78.9–80.7); Grade A (80.8–84.0); Grade A+ (84.1–100).

Table 3 shows that the overall reliability of UMUX-LITE, using aggregated data, is acceptable (Cronbach's α: 0.7). The 2000 sample bootstrap simulation generated a level of reliability slightly lower than expected (Cronbach's α: 0.65). The reliability analysis carried out for each group ranges from 0.69 (POCT 6) to 0.84 (POCT 4).

4.3. UMUX-LITE relationship with NPS

There is a positive correlation between the UMUX-LITE and NPS scores ($r = 0.455$, $n = 116$, $p < .001$). The anova one-way shows that there is a significant effect ($F(2,114) = 8.49$, $p < .001$) of satisfaction in the use of a device (aggregated UMUX-LITE) on willingness to promote (NPS: detractors, neutrals and promoters). This analysis was also confirmed by using the SPSS bootstrap function to simulate the analysis of variance at 1000 respondents ($F(2,114) = 3.13$, $p = .003$). Our data shows (see Fig. 1) that the higher the satisfaction score (UMUX-LITE), the more people are willing to promote the product (NPS).

Finally, a linear regression analysis showed that the TRL of the six POCT was a significant predictor of willingness to promote, detract or be neutral toward the technology ($F(3,113) = 41.13$, $p < .001$), with $R^2 = 0.49$ – i.e., the more the POCT is closer to the market (advanced stages of development) the greater is the intention to promote.

5. Discussion

Results of this study supported our expectations of UMUX-LITE, as follows:

- The scale maintains an acceptable level of reliability (Cronbach's α = 0.7) when used to evaluate the post-use satisfaction of POCTs. Although, the reliability identified in the present study is lower than the one reported in previous studies (Batbaatar et al., 2017; Borsci et al., 2015; Lewis et al., 2013), and the simulation, performed with a 2000 sample bootstrap technique, resulted in a Cronbach's α of 0.65.
- The satisfaction in use measure with UMUX-LITE positively correlates with the intention to promote the POCT with colleagues. This seems to confirm findings of studies carried out in other fields (Borsci et al., 2015; Lewis et al., 2013; Sauro and Lewis, 2016), and to

Table 2
UMUX-LITE satisfaction scores and grades for each POCT.

Type of POCT	TRL	% of satisfaction (UMUX-LITE)	CGS
1) Paper test for enzymatic analysis	4/5	**69.1%**	**C-**
2) High tech blood test	6/7	**76.5%**	**B**
3) High tech breath test	8/9	**73.2%**	**B-**
4) Low tech breath test	8/9	**70.7%**	**C**
5) Experimental breath test	6/7	**67.5%**	**C**
6) High tech test for acute coronary syndrome	8/9	**60.3%**	**D**

Table 3
Reliability analysis of UMUX-LITE for each POCT and for aggregated data, and 2000 bootstrap resampling simulation of the Cronbach's α confidence interval.

Type of POCT	TRL	UMUX-LITE Cronbach's α	Lower inbound	Upper Inbound
1) Paper test for enzymatic analysis	4/5	0.71	0.55	0.81
2) High tech blood test	6/7	0.72	0.4	0.93
3) High tech breath test	8/9	0.73	0.41	0.91
4) Low tech breath test	8/9	0.84	0.56	0.94
5) Experimental breath test	6/7	0.74	0.51	0.9
6) High tech test for acute coronary syndrome	8/9	0.69	0.39	0.82
Overall aggregated data		0.7	0.57	0.8
2000 sample bootstrap aggregated data sample		0.65	0.39	0.78

suggest that UMUX-LITE maintains its properties when applied in the health technology/medical field.

We have been able to test the relationship between UMUX-LITE, NPS and TRL by testing POCTs at different levels of readiness. We are unaware of previous studies that have analysed these relationships in the healthcare technology field. Our results suggest an important difference between UMUX-LITE and NPS:

i) UMUX-LITE is independent of the level of readiness of the technology i.e., people tend to assess their perceived usability on the basis of the product functioning, aesthetics and features. This enables UMUX-LITE to be used at different readiness level (TRL) to gather insights from end-users at the early stages of prototyping.
ii) NPS is sensitive to the level of readiness of the technology i.e. people tend to be more critical (detractors and neutrals) toward those products at early stages of development. This seems to suggest that end-users are more confident to express their intention to promote when they can interact with an advanced prototype instead of low fidelity ones.

These results suggest that designers and evaluators can use UMUX-LITE when they aim to assess, with repeated measures, people experience to new technologies at the early stages of design. This tool is limited in scope (i.e. one overall score) but is a reliable and quick measure that captures satisfaction with the healthcare technology. UMUX-LITE could be used to check the user satisfaction during the evolution of the product and after different stages of design. However, due to its limited scope UMUX-LITE should not completely replace other methods. This short scale should be used to prepare for more formal usability evaluation performed with comprehensive methods to establish efficiency, effectiveness and satisfaction. Our results demonstrate that measures of satisfaction could be better coupled with measures of the intention of use, such as the NPS, but only at advanced stages of product development.

6. Conclusion

The present work confirms that UMUX-LITE (composed of two items) can be used as a reliable tool to rapidly assess satisfaction toward the use of POCT at different stages of development. Manufacturers, researchers and practitioners may apply UMUX-LITE alone, or in combination with the NPS, to complement interviews and homemade scales to investigate the quality of new products. Although satisfaction and intention to promote are different concepts, these are related and a combination of those measures during the development of products may provide useful insights to developers to streamline their innovation. However, it seems that the NPS is affected by the readiness level of the technology and it could be combined with other tools only at advanced stages of product development.

Tools, like UMUX-LITE, could be used to assist during the design process of the product since from the early stages, and prepare the ground for a more comprehensive evaluation of usability. UMUX-LITE should not replace a full usability evaluation, nor will it provide the same level of insight as a longer and fully-validated scale, however, in the context of healthcare technology design in which busy professionals have a minimal amount of time to dedicate to support innovation, short and validated scales are important to enable manufacturers to rapidly adjust their technology to meet the needs of the end-users.

We acknowledge that this study has limitations due to i) a relatively small sample size (n = 120) of professionals involved in the evaluation,

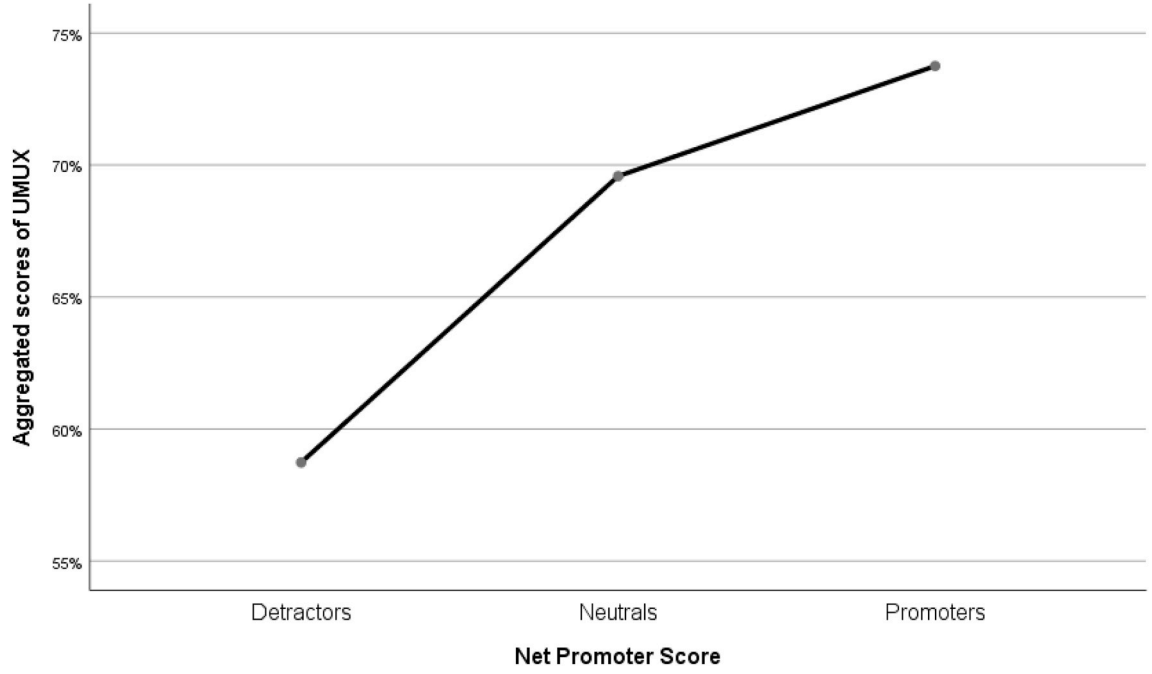

Fig. 1. Relationship between UMUX-LITE scores and end-users intention to promote, remain neutrals, or detract the product measured by NPS.

and ii) the fact that each POCT device was assessed by a different number of participants. We are aware that this tool needs further validation studies across a wider variety of systems.

Further studies are needed to investigate the use of satisfaction scales in healthcare technology and to operate the transfer of reliable practices and tools applied in other fields in the development of medical devices. These types of investigation may support those experts in the healthcare field attempting to understand the benefit and the limitations of new tools and practices. Moreover, these results may provide experts with further, reliable methods to assess new healthcare technology from the earliest stages of development.

7. Advances in methods and practice

What was already known on the topic:

- Satisfaction questionnaires are used to evaluate usability and correlate with scales to assess the 'likelihood to recommend' but little use is made of these in the medical field;
- The UMUX-LITE is a recently developed, short, two-items scale that can provide a quick and reliable tool for post-use satisfaction assessment. However, this had not been tested in the healthcare context.

What this study added to the methodological knowledge:

- The UMUX-LITE has acceptable properties when used to assess satisfaction in the use of POCT with healthcare professionals;
- UMUX-LITE correlates with a measure of 'likelihood to recommend' (the NPS) when applied in the health care context,
- UMUX-LITE can be used to measure user satisfaction with devices at different stages of product development, whilst the NPS seems to be a more proficient tool at advanced stages of design.

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