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Abstract. The aim of this paper is to identify the cultural usability aspects that need to be considered while internationalizing or localizing the interaction design of mobile keypads and displays for textual communication. The analysis is based primarily on heuristics tests, where: Hindi, Arabic and Danish mobile phones are evaluated based on assumptions of user needs, and in comparison to English. We have also referred the existing research on Chinese mobile phones to further complement our work. The study provides an insight into the much needed local-language centred approach in contrast with the current English centred approach of existing mobile keypad designs and display of text.

Keywords: Cultural Usability, Local Languages, Mobile Interaction Design, Mobile Usability.

1 Introduction

Today mobile phones are used extensively for writing and reading. Mobile phones are used as a medium for texting (SMS), but also for tasks that until recently were associated with computer use, such as emailing, reading news, surfing and even chatting online. In a lot of such everyday work and leisure situations, activities are usually done in the local language. The precise objective of a work related mail to another organization or a personal note to a family member can often be expressed best and fastest in the local native language.

As experts and researchers in interaction design and usability, and within learning and knowledge-based communication, we find that cultural usability in communication via mobiles on an everyday basis is an interesting phenomenon to study. Observing our own use and users around us, it became obvious to us that users meet obstacles when trying to write in non-native languages on the mobile phone. One of the authors of this paper developed a set of heuristics to evaluate the effectiveness of local language support in mobile phones. The heuristics were applied in a test of Hindi script and language use on three different brands of regular mobile phones. The findings from that study revealed several linguistic usability problems in mobile phones and cross-cultural issues between Hindi and English in the use of the phones. More specifically the study argued for standardization of keypad layout, *Devanagari* alphabetical rendering and Hindi translation of English technical terms

used in mobile phones [5]. When discussing the validity of the heuristics with respect to how well would they would transfer to other cultural and language settings, a range of examples came up that indicated that there might exists parallels but also some surprising differences across settings in the use of local language in mobile phones. In particular, the examples were surprising when considering a broad interaction design and use perspective on how mobile phones are used in everyday work and life for reading and writing. We decided therefore to carry out a, as close as possible, replication of the original heuristics investigated in the original study [5]; this time investigating the languages of Danish and Arabic, as well as looking at use of smart phones in comparison to regular phones.

This paper takes on a broader scope than the original study [5], and situates itself on a more thematic view of discussing the interaction issues that the tests in the three different cultural settings resulted in. The aim is to provide a necessary and much needed basis for discussing decisions regarding issues of internationalization and localization with respect to mobile phones, when writing and reading on mobile phones. The general understanding of these terms in software and design is that: *Globalization* is a one-size-fit-all strategy, whereas *Internationalization* is the process of designing a software application so that it can be adapted to various languages, user preferences, design requirements and regions without engineering changes; whereas *Localization* is the process of adapting internationalized software for a specific region or language by adding locale-specific components, design and translating. Localization seeks to create custom versions of software for each locale. [1,13,9]

The research question under investigation in this paper is:

> ***Which cultural usability aspects need to be considered while internationalizing/localizing the interaction design of mobile keypads and displays for textual communication?***

In the analysis this research question will be answered through photo evidences (that is pictures taken of screen and keypad, while carrying out the heuristic evaluation) of Danish, Hindi, Arabic mobile handsets and elaboration of the usability problems and how the culture specific user needs get compromised. In addition, we apply in our analysis the existing research on Chinese text input methods for mobile phones [6,7,12].

The heuristics were used to investigate usability of using language specific writing and reading interfaces in various mobile phones. English is investigated as base line study and is the originating script, which the phones were designed for. The three scripting languages, which have been the centre of focus of the study, were: Hindi, Arabic and Danish. The findings of the heuristic test accompanied with explorative observations of mobile use, point towards the advancement of localization (in an internationalization context) of mobile phones leading to better (more effective) communication between people, as language should not act as a barrier to productive mobile based textual communication in any social or organizational context in any country.

2 Literature survey

The discussion on whether to design using globalization, internationalization or localization strategy is relevant for any it-product to be used in cross-cultural settings; and is discussed often from both an end-user and economical rationale in the design literature [13, 1, 9]. A globalization strategy would be to apply the same uniform solution to everywhere, i.e. using English design and language for every country, whereas internalization strategies adapt the solution to the country setting by use of different languages, primarily by means of translation. A localization strategy in contrast adapts the solution not only by means of translation, but in particular considers cultural design changes as well. As such, Internationalization is a software development methodology that aims at minimizing modifications in software for different languages, writing systems, regions, or specific customizations. The purpose is to cut costs and work effort at the variation phase of software development. Localization in turn, is the process for adaptation of software and products to meet the requirements of local markets and different languages. Localization is often only seen as translation, or enabling translation, but when properly carried out, it also ensures and verifies the correctness of translations and correctness of cultural and linguistic conventions used. [13, 1, 9]

Culture and language are inextricably interwoven. As O'Neill [8] discussed when investigating customization of interfaces in general; It was found that patterns and norms for opening and closing conversations, turn-taking, asking questions etc vary depending on the language spoken by the person [8]. Consequently, for communication between mobile users and for communication between the technology and the user on a more detailed level (as when setting up the phone or new services and in particular when using wizards for this) local support is vital.

The literature today often focuses on the cultural differences between mobile users. For example Choi et al. [4] found in a study based on interviews with 24 people from three different nationalities (Korean, Japanese and Finnish), who were presented with videos of mobile services in use, that the Asian interviewees rely on symbols rather than on text, whereas 90 % of the Finnish participants disliked iconic menus. This can be regarded as an argument for local support, not only for writing, but also for general menus.

Similarly, arguments for local cultural support and design can be derived from Chavan [2] that describes differences in the cultural adaptation of mobile devices as compared to the original designed space, and about users, who do not conceive the perceived design as it was intended. Though not the primary objective of the paper, it shows how local support is important, and from a language perspective illustrates that support of local language and scripting is relevant, given that language and culture is interwoven. Also, there is a large group of users in almost every country, who do not speak or read English (literary millions of users) and non-English speaking citizens communicate with their family and friends in their local language.

It is also interesting how mobile email is winning terrain, accommodating for more work and study related communication and making the phone more and more an object for textual communication. In Japan, who is often researched as a first mover country within mobile use, a poll of 333 students habits showed e-mail was the most utilized mobile phone feature (more than voice calls) [15]. Also, 99% of the subjects

answered they used mobile emails, but only 43% send mails from PCs. These mobile emails had an average length of 200 Japanese characters each, which in the paper is said to be comparative to a paragraph of 70 words, and therefore much longer than standard SMS, which increases the information needed to be typed/read on the mobile device.

While investigating various navigation models, for selecting in large lists on a screen Chittaro and Marco[3] reports that the small screen of mobile devices is a serious limitation, because it restricts the user's ability to view and interact with large amounts of information. However, in a cross-cultural study from 2003 Sarker and Wells found among many other factors that users were less annoyed by physical limitations of the device due to technological constraints, but were bothered by flaws in the logical interface of the devices [14].

Sacher et al. [12] have elaborated the challenges of enabling products for interaction with Chinese customers. They describe how the "deficit-driven" approaches have been used for quickly identifying and addressing usability issues in interfaces which then resulted in fundamental disconnects between a product and a user culture. The deficit perspective can result in hard-to-understand and cumbersome products.

In a design study of an Arabic smart phone keypad (i.e. similar to PC qwerty keyboards with many keys compared to standard phones) Nanda and Kramer call for user interface designs that follows a language-cultural approach rather than reusing the context of use of one culture, by applying it design wise to another [11]. They refer to Katre's work [5], and also the heuristic test results reported on here, shows that there are indeed shortcomings in the logical structures of the local interface.

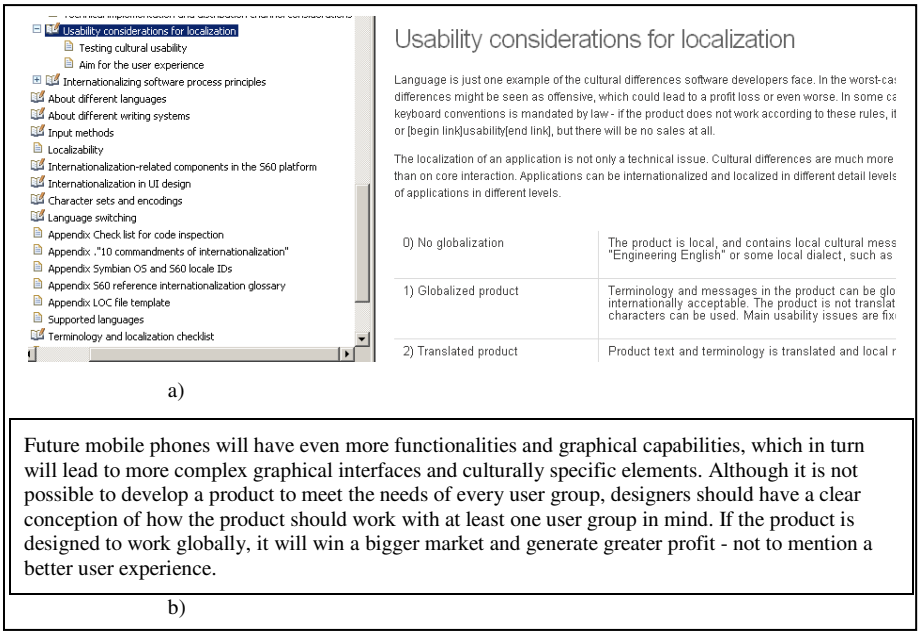


Figure 1. Nokia guidelines on internationalization and localization, source see [17]

However, it is clear that the various mobile phone producers do use energy on contemplating internationalization and localization issues, which responds to culturally varying user needs. As the figure 1, section a from the Nokia guideline website shows, the producers are concerned with more than merely translation rationales, but aims at maintaining a reasonable cultural specific usability and support of regional user needs. Though the quote shown in figure 1, section b, (which stem from the same report, but from the heading "Aim for the user experience"), indicates that there are contradictions. That Nokia at the same time aim at not only internationalization, but even globalization design strategies.

3 Lingua-cultural diversity

Before we investigate the effectiveness of localization and keypad/display design in mobile phones, we would like to appreciate the lingua-cultural diversity and scripts differences. Though this paper is not a linguistic investigation as such, but focus on cultural usability, we here outline the most important differences and those scripting differences, which are noteworthy, when it comes to writing on mobile phones. As mentioned, we focus on **English, Danish, Hindi** and **Arabic** language support on mobile phones, supplemented by existing research on **Chinese**. When local language script is shown as an example, we afterwards provide the Latin-written phonetics in hard-brackets, so as to clarify the combination of letters, for the non-local language readers.

Table 1. Comparative chart of language characteristics

	English	**Danish**	**Hindi**	**Arabic**
No. of Consonants	21	20	36	25
No. of Vowels	5	9	14	3
Numerals	10	10	10	10
Cursive style	No	No	Yes	Yes
Ligatures	No	No	Yes a lot 504 variations of conjuncts	No / few
Diacritic marks	No	Not compulsory	Yes and necessary	Yes, but few
Hyphens and other special characters	Yes	Yes, but seldom	No	Yes
Compound words	No	Yes a lot	No	No
Directionality	Unidirectional (left to right)	Unidirectional (left to right)	Unidirectional (left to right)	Bidirectional (left to right for numerals, right to left for alphabets)

Regarding the number of consonants and vowels: In **Danish** there is one less consonant than in English, because in Danish y is a vowel. The other vowels are æ, ø, å. Also, x, z and q are really not part of any indigenous words, though used for some

foreign words which has been adopted and used frequently today. In **Arabic** there are 28 letters, where 3 are considered the long vowels (ا و ي [alef, waw, ye]), but some local languages use other letters as well. In this study everyday classic Arabic and in particular Egyptian is used. The three languages are thus similar in turns of number of characters, whereas **Hindi** has 50 letters.

Hindi and Arabic uses cursive style, where the letters are joined and in Arabic the shape of the letters often change depending of whether it is in the beginning, middle or end of a word. In the table we have chosen no for English and Danish, as this is not the case when using traditional typesetting, and mobile keyboard input. When using special fonts as when people use hand-writing, cursive style is often used, where the shape of letters also changes. However, in Latin-letter typesetting, it is solely lower and upper case (capital) letters that are used.

Hindi (Devanagari scripting) use ligatures a lot, which further complicates the scripting style in particular when using keypads [5]. Ligatures are also found originally in Danish and Arabic, as in Danish the a and e is written as an æ, the a and a as å and the o and e as ø. Similarly in Arabic there are letters, like the ش [shin] which is a variation of س [sin] etc. However, these are already counted in the alphabet as individual characters (even though a few country wise adaptations also occur). In addition, there is the combination, which is sort of a mandatory ligature: the ل [lam] and ا [alef] into لا [lam-alef].

Diacritical marks are not used for indigenous words in English, but for some foreign words, which are now part of the English language and scripting style. Similar for Danish, including very old ways of writing, but they are not compulsory, they are very seldom used, and are primarily used to stress/accentuate a word. In Arabic they can be used, but is generally not and almost newer in typesetting modern Egyptian Arabic. Two to three often used exceptions occur, as the ء [hamza], but they are present on most keyboards/pads. Devanagari script of Hindi language merges the consonants and vowels together by using *Matras,* which are also referred as diacritical marks. On the other hand hyphenation and other grammatical marks are used in English. Consider for example the importance of placing the ’ correctly, as in students’ or student’s.

Thus the problem when trying to use non-latin languages on mobile phones is subtle. Consider the shape of the letters in the script. We could classify the Arabic and Hindi letters as very complex winding and asymmetrical. However, the Latin letters of English and Danish is influenced by the typographical standards, reaching back to the Gutenberg publishing tradition. The problem arising when typesetting in Hindi and Arabic is that the letters are “forced” into the same Latin-letter standard, which is not suitable to the same degree. This is because the shape is different, and not solely because it is more asymmetric, henceforth the difference of internationalization and localizations of the digitalized script.

In comparison to the above scripts, **Chinese** language stands out, because of its three characteristics: ideography, homophone and multiple-dialects [7]. The most obvious challenge in an internalization process of mapping the English keyboard to the huge number of Chinese ideographs, would be the [12]:

- 3,000 characters are the minimum for everyday communication.
- 20,000 characters (standard set).
- 50,000 characters (extended set includes names, scientific terms, etc.).

Having compared the scripts belonging to different cultures, we are in a better position to appreciate their differences and unique characteristics.

4 Cross-cultural HeuristicTest

In the following we provide a methodological outline of the foundation for the cross cultural heuristic test, considering the heuristics investigated, the linguistic scripting differences, as well as the more practical issues of which phones (brands and versions) using which language were tested.

4.1 Heuristics' for Bilingual Mobile Phones

Following 'linguistic usability heuristics' that were earlier applied for evaluating the effectiveness and usability of Devanagari support in Hindi mobile phones [5], we applied the same set of heuristics as [5], with an addition of one more heuristic related to memorability. The eleven heuristics are:

1. Represent the language in its original form
2. Maintain the original form and structure of script
3. Uniform representation of the language
4. Avoid influence of English or any other language
5. Maximum 4 alphabets / characters per key
6. Least typing effort
7. One-to-one correspondence between keys and alphabets typed
8. Avoid uncontrolled mixture and trade-offs between languages
9. 100% legibility of text
10. Readability / comprehensibility of text
11. Memorability of keypad layout and location of alphabet

These heuristics were applied for Danish, Hindi and Arabic mobile phones, whereas ee have referred the existing research on Chinese.

Figure 2. Arabic and Devanagari keypad layouts

4.2 What was Investigated?

An overview of the mobile phones used for gathering the empirical foundation of this paper is shown in table 2, where a description of languages and brief information on text input operators and the steps required for typing is provided. The test by Katre [5] was conducted before the Arabic and Danish tests, and only updated according to smart phones, also the ease of availability of the phones are not the same in the different regions. Therefore, it has not been possible to obtain the exact same phones, but we have instead at aimed at a cross-platform test (i.e. that the same producer is used in several regions, but not necessarily the same version of phone, as the Nokia 80 and 3105) as well as to test many producers.

Table 2. Comparison of text input mechanisms in different mobile phones

Mobile phone	Language	Keypad	Text Input Operators	Steps required
Blackberry	English	QWERTY Thumb keyboard	Single keystroke	• Single Keystroke
Nokia 3105	English Hindi	Standard English keypad	Multiple Keystrokes	• Press the key representing the appropriate group of alphabet, • Press it multiple times until you reach desired alphabet • For Hindi: Select the key for *Matra*
Nokia 80	English Danish	Standard English keypad	Multiple Keystrokes	• Press the key representing the appropriate group of alphabet, • Press it multiple times until you reach desired alphabet
LG RD5130	Hindi	Standard English keypad	Key press + Selection from on-screen options	• Press the key representing the appropriate group of alphabet • Press it multiple times until you reach desired alphabet • select half letters in case of conjuncts • Select the key for *Matra*
Samsung/Reliance C200	Hindi	Standard English keypad	Key press + Selection from on-screen options + Type associated numbers	• Press the key representing the appropriate group of alphabet • Press it multiple times until you reach desired alphabet • Press *Halant* for key joining the letters • Select the key for *Matra*
Motorola W230		Standard English keypad	Multiple Keystrokes	• Press the key multiple times until you reach desired alphabet
Sony Ericsson W810i	Arabic (using the Egyptian country code)	Arabic & Standard English keypad	Multiple Keystrokes	• Press the key representing the appropriate group of alphabet • Press it multiple times until you reach desired alphabet
Sony Ericsson Xperia	English Danish	QWERTY & touch screen	Single Keystrokes	• Single Keystroke • Handwritten strokes with multiple input pads

Cstar [7]	Chinese	Standard English keypad	Key press + Selection from on-screen options	• Type the pinyin • Choose the target phrase • Input the phrase(s) to get the symbol • Use directional keys for selection of alphabet

In addition, we looked briefly at the layout of many other phones and on pictures of them on the Internet, merely to get an idea of keypad layout. Rather than reporting on every issue in this paper, we found issues of particular interest when considering cultural usability in terms of the investigated cross cultural heuristic results, when using the mobile phone with local language / script support. It is these barriers and problems, as well as opportunities that are outlined underneath.

5 Discussion of Results

This section discusses the heuristic test results and consequences with respect to: Entering characters, words and usability of keypad design and display, etc.

5.1 Entering Characters

The heuristic test of **Hindi** mobile phones have already shown numerous discrepancies in the representation of language on the phones, non-standard keypad layouts and the huge effort to enter characters [5]. Illustrated in the description of steps required to enter text in table 2, entering characters require interplay between display and keypad, as will also be illustrated from a usability point of view below.

In **Arabic** even though the visual look and form of the alphabet is very different from the English, the number of letters is similar. This means when using the same layout strategy, each key ends up having 3 to 4 characters assigned. However, because many standard keypads use a form where both the Latin characters and Arabic are printed on to the keys, the keys becomes almost unreadable (figure 3), even for persons with exceptional good and young eyesight.

Though there used to be many different Arabic keypad layouts, almost all follows the same pattern today. The exception is primarily found on smart phones, and a search on pictures from phones on the Internet reveals that there are predominantly two layouts for full scale keypads for Arabic smart phones with small country specific variation, but the form used on PC's tend to prevail today. However, not everything function as it would appear visually. For example, it turns out that even though the keypad for the W810, shows the ت [te] as the third click on key number 3, the letter is in fact 4 clicks away. The character appearing after 3 clicks is the ث [Pe] used in Persian, Urdu and Kurdish, which is not illustrated on the physical key (figure 3). This happened on several keys on the w810. The maximum deviation was however always "just" one key press.

In general, ligatures and diacritical marks are found by pushing the corresponding letter (often several times), but where the most often used, like لا [lam-alef] would be part of computer keyboards, it is here found by writing these two letters after each other, and then the combination is automatically made. However, as the keypads do not show this, this has to be experimentally found (on trial-error basis). There are of course, as is also the case in Danish and English, many other special characters to choose from, with needs as much as 9 clicks before they appear on screen. Though they are rarely used, and for the most users perhaps newer used, the "interesting" part is to find them, as they are not illustrated on the pads, and they are not always placed at the same place in the phones, similar to Hindi and Devanagari writing discussed earlier.

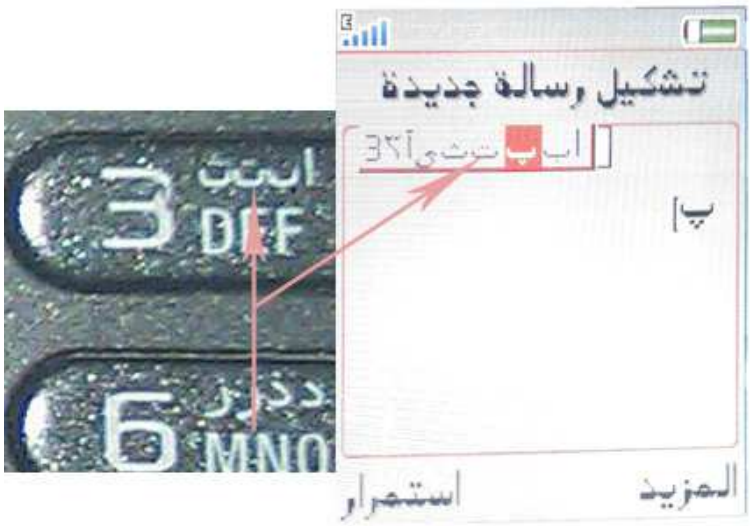


Figure 3. Discrepancy between illustrated and actual number of key press

Danish uses the same keypad layout as English, and almost all phones place the characters on the same number (exceptions are for example where the space key is found and a few seldom used punctuation marks, but again enough to confuse for example the speed of which the words of the heuristic test could be entered into various phones by the same test-conductor). Danish has only three letters that distinct it from the English alphabet; They are not visible on the phone, requires the user to know their placement and are used relatively often. That is, they are "reached" by pushing in the N80 case: Æ – push key no. 2, 5 times; Å – push key no. 2, 6 times; Ø – push key no. 6, 5 times.

Whenever there is a group of alphabets mapped on to each key, it becomes difficult to print those many alphabets on the key along with English. As a result, the manufacturers of mobile handset tend to print either the first alphabet in the group or first and the last alphabets in the group (refer Figures 2 and 3). It has been noticed that users often do not remember the groups of alphabet and hence they have to press each key to arrive at the desired alphabet [5].

When it comes to the use of smart phones, they often include either a stylus or virtual keyboard in qwerty-style for entering letters, or even in the most modern versions a physical keyboard. In the Xperia version it is however interesting to see how the placement of å is different from the typical Danish qwerty keyboard style (figure 4). For users who are used to writing without looking at keys at a regular qwerty-keyboard, this results in poor speed and disruption of flow in writing (which is especially interesting when investigating interaction with phones for writing mails for work).

Figure 4. Discrepancy between smart phone and PC QWERTY keyboards

5.2 Entering Words

In Choi et al [4] all of the interviewees (from 3 different nationalities) said that "minimal steps or keystrokes" was a significant attribute when using mobile data services, which is in accordance with Katre's maximum of 4 clicks for each letter in his heuristic test [5] that was repeated in this study.

Using the words "as long as" and "work" demonstrates use of words, using varied letters with respect to placement on the mobile, in all the three investigated languages (table 3). As "work" illustrates, it is easy to find words in Arabic writing that require more than the recommended 4 clicks at an average and even worse examples can be found. However, for illustrative reasons these words were chosen as they provided an interesting distribution among the three scripts. "As long as" in Danish not only use the special characters, which distinguish it from English, but also illustrates that Danish writing uses a lot of compound words, which neither of the other languages do. From a user perspective, on smaller screens, compound words can course interrupted readings with lots of scrolling, resulting in loss of flow, as sometimes only one word fit into each line. In newer phones and in particular smart phones as Xperia that allows for tilting of the screen and high resolutions, a more work-friendly environment for writing on the phones have been achieved. The results shows that in Arabic and Danish you can easily get pass the 4 clicks but in everyday writing for work and leisure, one would seldom get a lot pass that, and as is also illustrated one can even get a lot lower than that (1.6 for work in Danish).

In the original Hindi mobile test, a common word containing 3 + 1 conjunct letters was typed using different mobile phones, one of which required 55 keystrokes to enter the word [5].

In **Chinese,** Pinyin phrasal text input method is most frequently used in mobile phones. Each Chinese character / symbol is represented by a set of Roman characters, which makes this a cross-cultural hybrid solution since "Chinese [people] have to describe their language in a foreign script" [6]. There are several variations within the Pinyin method that are introduced by different mobile companies [7]. Similar, thoughts to restructure the keypad layout is seen even for English, where Mittal et al propose a layout based on the frequency of use of alphabet [10].

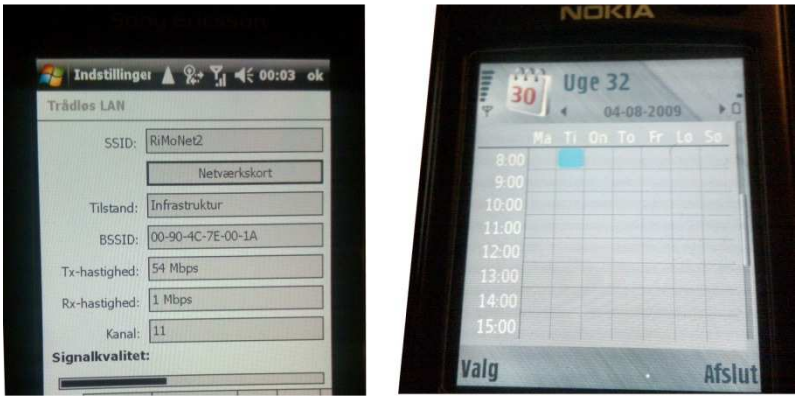
Table 3. Writing words on mobile phones, the N80 and W810 (the Egyptian word for work is used here (in classical Arabic عمل [3amal] would be used).

Test word	Danish	Arabic
As long as	Sålænge	تول ما [tul ma]
21 clicks for 10 letters (incl. space)	23 clicks for 7 letters	13 clicks for 6 letters (incl. space)
2,1 clicks per letter	3,3 clicks per letter	2,2 clicks per letter
Work	Arbejde	شغل[Shurghl]
9 clicks for 4 letters	12 clicks 7 bogstaver	11 clicks for 3 letters
2,25 clicks per letter	1,6 clicks per letter	3,7 clicks per letter

5.3 Use of English in Local Language Interfaces

Investigating the interface, it turns out that use of the Danish language is very well adapted in both types of phones, In both the regular and smartphone, the use of Danish even applies to places where one would expect a lot of technical English terms. This is true for example when formatting network connections as well as using other applications as the calendar (figure 5). Arabic was not fully adopted. For example there seem to be a consequent use of numbers. Even for basic items as showing the time, date and phone calling at the "front page" of the phone. But also in the menu for setting up various items (in the screen it says 10 minutes, where minutes is in Arabic, but 10 is not), and the calendar uses abbreviations and numbers in English (figure 5).

Hindi Localization



Danish Localization

Arabic Localization

Figure 5. Top pictures: Motarola W230 in Hindi, Xperia (in the middle to the left) and N80 (to the right), below both pictures from W810.

Based on a number of sources, users at Wikipedia have listed the number of English speaking persons according to the population [18]. The list states that nearly 11% of Indians understands and use English, which is app. 90 millions. In Denmark this percentage is as much as 86%, but this only adds up to app. 4,7 millions. Similar correlations, though less in volume, can be found for many Arabic countries, who also have large populations, but less percentages who know English compared to Denmark. With this huge difference, it is interesting how well the Danish phones support Danish, and how poorly the mobiles support Hindi and Arabic language. The heuristic test found that from an input perspective, of writing Arabic on the phone, the support on phones are good, but the test also found that in the interface on the phone, the local language support was not as well integrated as the Danish was. In the situation of Devanagari, both reading and writing is problematic.

From a market perspective the difference does not make sense. It should not only be because the alphabet is based on Latin letters that the Danish support is more rigorously implemented. Once the ability in the mobile software is present to use local script of any sort, it is merely a matter of translation. Perhaps with the exception of words with a system-like nature as "Bluetooth". Henceforth, at a current stage Hindi and Arabic could be equally well supported. Historically, it could be a matter of economic and buying-ability/behavior. Denmark has been known for being the country with a large amount of IT-equipment per capita and with a quick first mover market, which would make even a small market financial interesting. With today's use of mobile phones in Asia and Eastern countries and the huge number of users compared to Denmark, this do not make sense, and from a cultural usability point of view, this is interesting, and looks somewhat cultural political.

6 Conclusion - Enhancing the cultural usability of mobile phones for textual communication

Through this paper, we have attempted to take an overview of 5 different languages and how they are supported on mobile phones. It is obvious that the standard keypad layout of mobile phones consisting of 12 keys is primarily designed for English language. English has evolved as a digital script over many years unlike the other world languages which are very different from each other and far too complex e.g. Hindi and Chinese. All languages are different in terms of number of letters, scripts, rules and usage.

Mobile phone producers seem to have forcefully attempted to fit these languages on 12 keys using the English standard method of writing with multi keystrokes. This has resulted in unnatural solutions for accessing the alphabet such as use of English words for referring to Chinese letters or association of numbers with alphabet and selection from on-screen options.

The size of the keys or buttons on the mobile phone is also a matter of design from localization perspective. Labeling the buttons with a group of alphabets in Hindi or Arabic along with English alphabets becomes difficult due to small size of buttons. As a result, many times all alphabets mapped on a button are not labeled. One has to discover them on screen by pressing the button.

As we have pointed to earlier, there are designers working with alternative solutions to the 12 keys. The argument is that if the language has a large number of letters then an associated number of keys must be provided. E.g. on-screen keypad layout of HID3 Nokia tried out by Yan [16] has 63 keys for Chinese script.

There should be maximum 4 characters on a button, as one tends to skip the alphabet during multiple keystrokes [5]. But this heuristic rule appears to be violated even in Danish script which is closer to English. The screen size and resolution of mobile phone is crucial as complex alphabets can be difficult to render in small screens. Ultimately it impacts the readability of text in combination with the "squeezing" of the local scripts into the Latin-letter standard as previously discussed. The Danish æ (the a and e in Danish) becomes quite small in typesetting. The problem arises, as the square-standard tend to be globally used as generic. In particular, in Hindi and Arabic this pose problems, as that these two languages are always using the letters joined together. Having to make room for also connecting lines and letters that are quite big, like the Arabic ش [shin] or the Hindi आ [aa], puts an extra difficulty when writing and reading on mobile phones.

Arabic and Hindi calendars shown in figure 5 are evident enough to indicate that the font styles do not match with English. In this example, Arabic script is using calligraphic strokes while English is using equal thickness font. Due to unavailability of matching fonts the localized labels tend to not fit properly in the provided space.

Whenever we have come across scripts with large number of alphabets and diacritical marks, the techniques for entering words is a combination of Keypad + on-screen options for selection of alphabet / associated numbers / meaningful words [16], However, External keypad layout and internal distribution of local language, encoding of alphabets vary from phone to phone [5]. As a result, the textual communication as SMS, can't be read on heterogeneous mobile handsets. This can be achieved only if the mobile fonts are standardized.

Figure 5 shows that calendars in Arabic and Hindi continue to use English numbers. From the heuristic test perspective the localization procedure is not settled, not only in terms of alphabets, but numerals and other symbols.

7 Design and Research Perspectives in relation to the Research Question

The objective of the paper, according to the stated research question, was to investigate ***Which cultural usability aspects need to be considered while internationalizing/localizing the interaction design of mobile keypads and displays for textual communication?*** Through the discussion of the results and conclusions of the heuristic test we have shown, that there are many aspects that can be directly taken from expert evaluations. These can to some extend be directly translated in to design considerations. We have identified the following cultural usability aspects related to internationalization and localization of mobile phones:

1. Local-language-centred keypad design to co-exist with English [5, 11]
2. Size of button / key (Refer figure 3)

3. Adequate number of buttons necessary for representing a language
4. Minimum number of letters to be mapped on a key (Refer 4.2)
5. Display size and resolution for proper and legible rendering of the script [5]
6. Local language fonts matching with English in terms of size, thickness of strokes [5]
7. Standard guidelines "key + on-screen options for selection of alphabet" method (Refer Table 2.0)
8. Availability of standard fonts across heterogeneous handsets
9. 100% localization including numerals (Refer figure 5.)
10. Guidelines for internationalization of mobile keypad design, local language fonts, text input mechanism, mobile software design and user interface design need to be evolved on similar lines as W3C I18n. It should go beyond local language issues and also cater to all culture specific design preferences to attain the goal of cultural usability.

However and not surprisingly, in our work we have also found that cultural adaptation of mobile phones in use, takes place in many ways. For example the tendency to write phonetic Arabic and Hindi, using Latin letters, even in situation where the mobile phone one owns support the local language script. Though this is certainly partly due to missing adequately localized design, it is also a pattern of adaptation that needs investigation. There is thus a need for further clarification by investigating how people read and write on phones in their everyday use.

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