Towards a Toolbox for Intercultural User Interface Design

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Abstract: In this paper, a method-mix (cultural dimensions, intercultural variables, user interface characteristics and human computer interaction (HCI) dimensions) for intercultural user interface design (IUID) is presented. Based on a hybrid approach covering cultural contexts in human–computer interaction (HCI) design using a model of culturally influenced HCI, this IUID method-mix represents the main constituent of a reasonable toolbox for IUID. The IUID method-mix is exemplified by application examples to demonstrate and discuss its benefit and limitations. The examples elucidate why and how cultural aspects play a role in HCI design and usability/UX engineering. Cultural influence on HCI is described using cultural variables for user interface design. The IUID method-mix serves to inspire HCI engineers in the requirement analysis phase as well as HCI designers in the design phase. The readers are sensitized to the challenges of intercultural usability/UX engineering and intercultural HCI design and will be equipped with relevant methodological knowledge needed to actively derive design recommendations for user interface design for and in their desired cultural contexts. Practitioners can prognosticate the ensuing effort and the expenditure for considering cultural context in intercultural user interface design.

1 INTRODUCTION

Intercultural user interface design (IUID) is a prerequisite for improving the intercultural usability of software, which in turn is a prerequisite for global sales opportunities (Heimgärtner, 2019a). Using methods of intercultural usability engineering, further design guidelines for IUID can be iteratively derived from the results of the tests and the feedback of potential users from all over the world. Hence, the perception and consideration of the customs and requirements of other cultures by the developers of intercultural user interfaces is one of the main tasks within intercultural user interface design. Based on feedback from tutorials, workshops and courses on IUID and the revised summary of the state of research on IUID in (Heimgärtner, 2014), the author reviewed the synopsis of well documented IUID methods to come to a reasonable toolbox for IUID, consisting of a IUID method-mix, which will be presented, explained, exemplified and discussed in this paper using an application example.

2 BACKGROUND AND RELATED WORK

Differences between cultures can be found by analysing critical interaction situations between people (Thomas, Kinast, & Schroll-Machl, 2010). (Honold, 2000) made this method available for cultural differences in Human-Machine Interaction (HMI): critical interaction situations that arise due to problematic functionality of user interfaces must be analysed. (Vöhringer-Kuhnt, 2002) found that e.g. Hofstedes "Individualism Index" (cf. (G. H. Hofstede, Hofstede, & Minkov, 2010)) is related to user satisfaction and usability of the product and has a significant influence on intercultural usability. (Röse, 2004) proposed the "Method for Culture-Oriented Design" (MCD), which integrates the factors of new concepts of culture-oriented HCI design and the knowledge of cultural differences into existing concepts of HCI design. Relevant cultural variables for intercultural HCI design must be determined analytically based on literature and requirement studies. Their values represent culture-

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dependent variations that occur at all levels of HCI localization (surface, functionality, interaction) and that can be used for IUID. Similarly for culture-oriented design, (Shen, Woolley, & Prior, 2006) considered a simplified version a culture-centred HCI design process while focusing on social and cultural aspects in order to cover the value of the user's cultural context. Further methods are applying user interface characteristics (Marcus, 2006) or cultural markers (Badre & Barber, 1998). To make cultural dimensions available for user interface design, (Marcus, 2006) developed characteristic factors for user interfaces and gave examples that can influence user interface design (such as different colours or behaviours). Cultural markers have been determined by empirical studies (e.g., (Badre & Barber, 1998), (Dormann, 2006), (Sun, 2001)), which are specific for a certain culture and which are preferably used within this certain culture (such as flags). Other approaches, e.g. by (Castro, Luciana, Leitão, & Souza, 2013) or (Pereira, Baranauskas, & Liu, 2015), are based on semiotic theory. In semiotic engineering, HCI is seen "as a two-tiered communicative process: one is the designer-to-user communication and the other is the user-system interaction. [..] HCI can only be achieved if both levels of communication are successfully achieved." (Souza, Barbosa, & Prates, 2001): 55.

One of the most promising methods to discover cultural differences in HCI is the comparative observation and analysis of user interaction with the system (cf. (Heimgärtner, 2012)). The results of observations of cultural variables and their manifestations serve as a basis for:

- cultural adaptation of user interfaces (cf. (Heimgärtner, Holzinger, & Adams, 2008));
- guidelines for IUID (e.g. cultural interaction indicators (cf. (Heimgärtner, 2012));
- a culture dependent HCI model (cf. (Heimgärtner, 2013));
- culturally aware systems (cf. (Heimgärtner, 2018)).

3 PATH TO A IUID TOOLBOX

The path to an initial version of an IUID toolbox is described as follows: First, the used concepts for the toolbox are presented. Second the integration of the combined use of the concepts within one hybrid approach is explained. Third, the application of the IUID method-mix as the main functionality provider for the IUID toolbox is exemplified. The most relevant aspects and important constituents deriving recommendations for IUID using the IUID toolbox are elucidated. Together with the application procedure for the IUID method-mix, consisting of steps of how to reasonably use the properly arranged methods, the way to a toolbox for IUID is paved.

3.1 Concepts Used: IUID Method-Mix

The IUID toolbox uses a hybrid approach integrating a combined use of the following concepts ("IUID Method-Mix" for short) to derive cultural HCI indicators relevant for the derivation of recommendations for IUID:

- HCI dimensions;
- Cultural dimensions;
- Intercultural variables;
- User interface characteristics;
- The culture dependent HCI model;
- The method of culture-oriented design.

3.1.1 HCI Dimensions

HCI dimensions represent classes of HCI variables useful for HCI design describing the behaviour of a user (HCI style) with an interactive information processing system (Heimgärtner, 2013). HCI dimensions are expressed by information science variables such as information density or interaction frequency at the interaction level (Heimgärtner, 2012). In order to measure the parameters, the characteristics of the HCI dimensions must be very precise and concrete. Therefore, the HCI dimensions are operationalized in many quantitative variables (HCI indicators) in order to obtain a basic HCI metrics. There must be at least one HCI indicator as a measurement variable in order to represent the characteristics of an HCI dimension. For real use, however, several empirically proven HCI indicators should be employed.

3.1.2 Cultural Dimensions

Cultural standards (i.e., orientation systems according to (Thomas et al., 2010)) and cultural dimensions (e.g., individualism vs. collectivism, uncertainty avoidance, long term orientation and masculinity vs. femininity from (G. H. Hofstede et al., 2010) or action chain orientation, network density and context orientation from (Hall & Hall, 2009)) serve to describe and compare cultural systems. The characteristics of cultural dimensions influence the user experience and provide orientation for the usability engineering process. Differences between cultures can be found by analysing critical interaction situations between people (Thomas et al., 2010). The mental model of the user about the system depends on

the culture of the user, his expectations about the characteristics of the system and his experience of interaction with the system. The cultural aspects and their manifestations can be empirically determined using qualitative and quantitative methods.

3.1.3 Intercultural Variables

Cultural dimensions are too rough for IUID. For this reason, additional cultural variables are necessary which – in relation to user interface design – divide the cultural aspects into smaller units (cf. (Röse, 2004)). Intercultural variables describe the differences in HCI design with respect to the preferences of users from different cultures. Direct intercultural variables are most important because they have a direct and essential influence on the HCI design. "Visible" intercultural variables are immediately perceptible at a certain time (font, colour, window size, navigation, etc.). In contrast, "invisible" (or "hidden") intercultural variables are only recognizable over a certain period (such as interaction speed, information display duration, dialogue display frequency, use of the navigation bar).

3.1.4 User Interface Characteristics

The user interface characteristics "Metaphor", "Mental Model", "Navigation", "Interaction" and "Presentation" can be linked to Hofstede's cultural dimensions ((G. H. Hofstede et al., 2010), (Röse, 2004), (Marcus, 2006)). User interface characteristics can be used in conjunction with empirical surveys on their characteristics for the corresponding cultural target context to derive recommendations for the development of intercultural user interfaces.

3.1.5 Culture Dependent HCI Model

Cultural models and cultural HCI indicators, which have been generated by the analysis of user interaction, can be used to describe the needs of the user in terms of the HCI depending on his culture as well as to develop an explanatory model for culturally influenced HCI and to improve the methods of intercultural usability engineering. With the help of a culture dependent HCI model, examples of different culturally conditioned behaviour of users with interactive systems can be explained. For this purpose, the explanatory models must be determined based on analytical considerations and verified using empirical data and statistical methods. Successful explanatory models can be applied to new examples or application cases and thus verified, which in turn allows predictive design recommendations to be generated.

3.1.6 Method of Culture-Oriented Design

The "Method for Culture-Oriented Design" (MCD), integrates the factors of culture-oriented HMI design and the knowledge of cultural differences into existing concepts of HMI design (Röse, 2004) (cf. Figure 1).

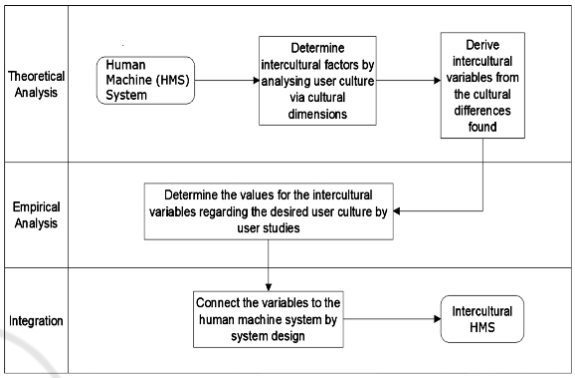

Figure 1: Simplified version of the Method of Culture-oriented Design (Source: (Heimgärtner, 2012): 66).

3.2 Connecting HCI to Culture

One important goal for intercultural HCI designers and intercultural usability experts is to consider fundamental cultural differences when dealing with members of cultures interacting with machines. Hence, the most important step is to bridge the gap between cultural aspects (e.g. derived from cultural dimensions) and HCI design by determining relevant cultural parameters for IUID using analytical research tools and doing evaluation by empirical studies. The aim is to find the actual connection between HCI indicators and their (postulated cultural) causes represented by the relationship between cultural and HCI dimensions (and their variables respectively). To solve this, a structural equation model for the relationship between HCI and cultural dimensions has been generated (Heimgärtner, 2012). The connections between cultural, information-related and interaction-related dimensions were modelled using cultural HCI indicators. Results found applying this approach (Heimgärtner, 2012) led to the conviction that it is justified and useful to use cultural HCI indicators for intercultural HCI research in order to obtain a reasonable explanatory model for culturally influenced HCI (Heimgärtner, 2013). The explanatory model is based on some of the best-classifying cultural HCI indicators, indicating that the

expressions of the HCI dimensions depend on the cultural imprint of the users, which can be described by the expressions of cultural dimensions: the higher the relationship orientation (collectivism), the higher the information density, information speed, information frequency, interaction frequency and interaction speed (and vice versa).

This supports the assumption that further connections between cultural dimensions and HCI dimensions and cultural interaction indicators can be modelled and explained using structural equation models as a basis for the application of the IUID method-mix, which applies for the rationale to create a IUID toolbox.

Figure 2 shows the content of the culture dependent HCI model representing the hypothetical relationships between cultural and HCI dimensions (Heimgärtner, 2013).

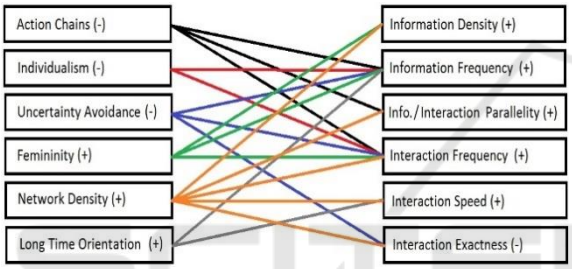

Figure 2: Hypothetical Relationship Between Cultural and HCI Dimensions (Heimgärtner, 2013).

The model contains the following rules expressing the connection between the values of the cultural dimensions and the values of the HCI dimensions, thereby determining the denotation level for culture and HCI (cf. for details (Heimgärtner, 2013)):

1) The lower (-) action chain orientation:
a) the higher (+) information frequency (IN-F).
b) the higher (+) information parallelism (IN-P) and interaction parallelism (INT-P).
c) the higher (+) interaction frequency (INT-F).
2) The lower individualism index (IDV):
a) the higher information frequency.
b) the higher interaction frequency.
3) The lower uncertainty avoidance index (UAI):
a) the higher information frequency.
b) the higher interaction frequency.
c) the lower interaction exactness (INT-E).
4) The lower masculinity index (MAS):
a) the higher information density (IN-D).
b) the higher information frequency.
c) the higher interaction frequency.
5) The higher network density and context orientation:
a) the higher information density.
b) the higher information and interaction parallelism.
c) the higher interaction frequency.
d) the higher interaction-speed (INT-S).
e) the lower interaction exactness.
6) The higher long-term orientation index (LTO):
a) the higher information frequency.
b) the higher interaction-speed.
7) And vice versa for all six rules (i.e., for Rule 1: the higher action chain orientation, the lower information/interaction frequency and parallelism).

According to the changed values of the cultural dimensions on the left side of the model (antecedences in the "production rules" in Figure 2), the values of the HCI dimensions change on the right side of the model (consequences in the "production rules" in Figure 2). Therefore, this model does not depend on nations or countries but can be used to cover every cultural group (with at least 20 members, if using Hofstede's Values Survey Module (VSM) (cf. (G. Hofstede, 1994)) to determine the cultural characteristics of the group).

3.3 IUID Toolbox

Using the reasonably arranged and applied IUID method-mix defined by a properly selected integration procedure embodies the contents of the IUID toolbox. The IUID toolbox applies the IUID method-mix, which consists of a combined use of cultural dimensions, intercultural variables, user interface characteristics, HCI dimensions and the model of culture dependent HCI in a systematic way to derive IUID recommendations (Heimgärtner, 2019b).

3.3.1 Systematic Procedure for Deriving IUID Recommendations

The hybrid approach integrating all the mentioned concepts above by a systematic procedure to analytically derive recommendations for IUID is described in detail in (Heimgärtner, 2019b). The procedure to derive IUID recommendations is as follows: First, the application, main uses cases and the desired target cultures are chosen. Depending on the use case, the respective UI elements (e.g. layout, buttons, text fields) have to be determined and mapped to the category of the cultural variables (direct, indirect, visible, hidden) as well as to the user interface characteristics (presentation, interaction, navigation, mental model and metaphor). Using this information, the time and space related HCI dimensions must be identified (such as information

density or interaction frequency). Via the rules of the explanatory model of culture dependent HCI, the related HCI dimensions must be connected to the cultural dimensions to obtain relevant cultural HCI indicators. Having the cultural HCI indicators in hand, recommendations for IUID can be drawn according to the designated culture of the user.

3.3.2 Exemplifying This Procedure

Table 1 shows the output of using the IUID toolbox (i.e. the results obtained by systematically applying the IUID method-mix).

Table 1: Results by Using the IUID Toolbox.

Application(s)	Word processor on a mobile phone
Use Case(s)	Sending a text message via SMS
Cultural Dimension(s)	Power distance, individualism, uncertainty avoidance
User Interface Characteristic(s)	Presentation: text, character, character set, layout, skin, edit field, send button, receiver list box
Intercultural Variable(s)	Direct, visible, surface (language, color, layout, skin)
HCI Indicator(s)	Number of pieces of information per space, number of SMS per day, number of saved contacts
HCI Dimension(s)	Information density, interaction frequency and speed, information and interaction parallelism, interaction exactness
Culture Dependent HCI Model	China (IDV low ➔ IN-F high, INT-F high; UAI low ➔ IN-F high, INT-F high, INT-E low), Germany (IDV high ➔ IN-F low, INT-F low; UAI high ➔ IN-F low, INT-F low, INT-E high)
Cultural HCI Indicator(s)	Number of pieces of information per space, number of SMS per day and number of saved contacts vary from low to high
IUID Implication(s) / Recommen-dation(s)	Adapt system memory; choose appropriate input method editor (IME) and sorting algorithms; allow customization of the number of entries in lists

Assume, a UI designer wants to identify design recommendation for IUID for users from China or Germany regarding an application with the use case “sending a short text message via SMS on a mobile phone”.

The first step is to identify the cultural dimensions representing the highest cultural distance between the target cultures. The value of the cultural dimensions can be looked up in the literature of culture experts (such as (G. H. Hofstede et al., 2010) or (Schwartz, 2004)). According to Hofstede’s cultural compass, these are the power distance index (PDV), the individualism index (IDV) and the uncertainty avoidance index (UAI) (cf. (G. H. Hofstede et al., 2010)).

The next step is to identify the UI elements (e.g. text, characters, character set, layout, skin, send button, receiver list box) that are concerned in the use case and to relate them to the user interface characteristics (e.g. presentation).

Now, the mapping of the UI characteristics to the intercultural variables is to be done. Presentation concerns direct, visible cultural variables on the surface of the user interface (such as language, colour, layout, skin).

Having the localization levels (surface, interaction, functionality) and the intercultural variables in mind, corresponding HCI indicators (operationalized quantitative variables) such as the number of pieces of information per space, the number of SMS per day and the number of saved contacts can be identified.

Consequently, similar HCI indicators can then be grouped to the fitting HCI dimension. For example, the variables “number of pieces of information” and “number of saved contacts” can be related to the HCI dimensions “information density” (IN-D).

The relationship between cultural dimensions and HCI dimensions comes into play by following the rules of the explanatory model expressing the connection between the values of the cultural dimensions and the values of the HCI dimensions (cf. Figure 1). For instance, IDV is related to information and interaction frequency and UAI is related to information and interaction frequency as well as to interaction exactness. If individualism in a culture is low (e.g. for China in contrast to Germany according to (G. H. Hofstede et al., 2010)), then information frequency and interaction frequency tends to be high (e.g. for China in contrast to Germany according to (Heimgärtner, 2013)).

Furthermore, HCI dimensions are also related to UI characteristics. For example, information density is affected by the cultural *presentation* requirements (cf. culturally different communication patterns, (Lewis, 2000)). This different communication behaviour can be expressed using adequate cultural HCI indicators such as number of pieces of information per space, number of SMS sent per day or number of contacts.

This in turn leads to the following requirements for system design and recommendation for IUID: The

HCI system at hand needs to have enough memory for storing contacts and sent short messages. Furthermore, it needs an input method editor for the different character sets in China and Germany in order to quickly choose and select the desired receiver name from an adequately sorted list. Moreover, the user interface should be customizable to the number of presented pieces of information, e.g., the number of entries in lists or menus (cf. hierarchical versus flat menu structure, (Gould, Marcus, & Chavan, 2006)).

The entire model consists of more than 300, mainly quantitative, potential parameters that are relevant for intercultural HCI design and, depending on the culture, have been analytically established by literature research (cf. for details (Heimgärtner, 2012)) and can be used to support analytic processing.

These reflections can also be used for culturally adaptive systems (Heimgärtner et al., 2008) that can automatically change the user interface characteristics according to the cultural needs of the user because they are already aware of them by design or becoming aware of them by learning over time (Heimgärtner, 2018).

4 DISCUSSION

In the following, considerations applying the culture dependent HCI model and evidence for the proper application of the IUID method-mix are discussed elucidating why and how cultural aspects play a role in HCI design and usability/UX engineering thereby showing the strengths and weaknesses and possible alternatives regarding the approach, usefulness and limitations of the IUID toolbox.

4.1 Strength of the Scientific Basis

The results so far serve to reveal a basis and some proven facts that are useful for the acquisition of general recommendations for trends in intercultural HCI design (cf. (Heimgärtner, 2012)) and culturally adaptive systems (cf. (Heimgärtner, 2018)). The "Intercultural Interaction Analysis Tool (IIA-Tool)" (Heimgärtner, 2008) served to record and analyse the user's interaction with the system to identify culture dependent variables such as colour, positioning, information density, and interaction speed as well as their values, which enabled the verification of parts of the culture-dependent model of HCI as well as preliminary design rules for intercultural HCI design (Heimgärtner, 2012). With the right combination of cultural HCI indicators it is possible to get HCI differences that are purely culturally imprinted (Heimgärtner, 2012). Therefore, the cultural differences in HCI found are quantitatively measurable by a computer system using special combinations of cultural HCI indicators represented by cultural HCI patterns (cf. HCI style in sections 3.1.1 and 4.2) depending on the culturally imprinted behaviour of the user with an interactive system. This means that the analysis (recognition and classification) of cultural HCI patterns and cultural differences in HCI can be achieved purely quantitatively (Heimgärtner, 2012) - a handful of cultural HCI indicators is enough for this purpose, which also serves for culturally adaptive and aware systems (cf. (Heimgärtner, 2018)). Cultural HCI patterns representing the cultural differences in HCI and the derived cultural HCI indicators are sufficiently statistically discriminating to detect them and to relate the users to a certain cultural imprint (cf. (Heimgärtner, 2012)).

4.2 Usefulness of the IUID Toolbox

The results so far led the author to the concept of intercultural HCI style scores, which can be computed for the designated cultural group from Hofstede's indices in order to estimate the development expense for new IUID projects. The intercultural HCI style score expresses the average degree of information density and frequency as well as interaction frequency and speed the members in the designated cultural group expect according to the culture dependent HCI model (Heimgärtner, 2013). From Hofstede's data, one can infer, for example, that the cultural distance between China and Germany is high in contrast to Austria and Germany, which is also reflected in the HCI style score and therefore in the behaviour of the user interaction with the system. Although cultures are constantly changing, at least for a product life cycle of a few years, trends can thereby be determined, and for special cases of application even selective parameters can be determined, which serve IUID projects.

4.3 Limitations of the Approach Today

Many aspects must be considered simultaneously to obtain possible cultural explanations for their effect on HCI. One cannot predict how the single parts of the cultural puzzle will fit together (cf. (Hall & Hall, 2009)). This has implications for the methods used in intercultural HCI design and in intercultural usability engineering (cf. (Nielsen, Bødker, & Vatrapu, 2010)). For example, the localization of hidden intercultural variables is very difficult to realize because the

contextual relation to the cultural background as well as to the product is very strong for interaction and dialogue design. However, it is precisely this culturally distinct context and consequently the cultural dependency thereupon that these patterns and non-visible intercultural variables are so important for information architecture as well as for interaction design and, hence, for the resulting dialogues (Röse, 2004).

Parallel to extensive research literature, empirical investigations regarding intercultural user interface characteristics are necessary, more specifically by comparing several systems of different cultures (benchmark tests) as well as usability evaluation (usability testing). For example, the separation degree of intercultural variables and cultural HCI indicators must be improved by future research (e.g. by extending the number of considered cultural dimensions and related cultural HCI indicators).

The rules developed within the model presented above represent tendencies describing the relationship between cultural dimensions and HCI dimensions. Until these assumed connections are not completely empirically verified, the model is not very resilient. Therefore, much research effort is still necessary because of the number and complexity of the relationships in HCI determined by culture.

For example, the average HCI style score of the designated cultural group can be computed from the model represented only by those rules for which Hofstede's indices are known. Factor analysis to statistically cluster Hofstede's indices according to their HCI style should refine the currently assumed rules that describe the relationship between cultural imprint and HCI style of a group.

To avoid the evaluation effort of culture dependent HCI models, the revised principle of culturally adaptive HMI (cf. (Heimgärtner, 2012)) could be applied abstaining from cultural categorization at all - as already required by (Rathje, 2003). This principle suggests, instead to use cultural dimensions, to detect just the pure HCI style of the user and adapt the HCI accordingly. However, both, the culture dependent HCI model as well as the revised principle of culturally adaptive HMI must be extended and empirically validated.

5 CONCLUSION AND OUTLOOK

The IUID Toolbox represents a hybrid approach integrating several cultural methods and applying them systematically. Using the hybrid IUID method-mix is a reasonable approach towards an IUID toolbox integrating the methods and the explanatory model of culture dependent HCI. Areas such as intercultural usability engineering and intercultural user interface design (IUID) can benefit to the extent that the model is further developed and empirically validated to be successfully applied to new applications, use cases and products allowing predictive recommendations for IUID.

Even if not all aspects of the approach to the IUID Toolbox and the resulting IUID recommendations have been empirically proven yet, it is very reasonable (or even necessary to have first hypotheses) for further development and research to consider some rules of thumb. On the one hand, they must be regarded provisional and should therefore still be treated with the greatest possible care. On the other hand, they provide an informative basis for new IUID projects and serve to estimate the development expense of them in advance.

The final version of the IUID toolbox should enable the derivation of IUID recommendations based on the current state of research in IUID. Integrating the IUID method-mix and the systematic procedure for its use into an application for developers of intercultural user interfaces can be the basis for an empirical evaluation of the IUID toolbox and its features for the future.

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