Contract no. 034106

Delivering Inclusive Access for Disabled or Elderly Members of the community

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Final Activity Report – Annex II

Extending Online Forms Accessibility Guidelines for Elderly and Cognitively Disabled Users

Unrestricted.

Lead Contractor for Deliverable: Brunel University Project Start Date: 1 September 2006 Duration: 40 months	Revision: V1.0 Date: 15 June 2010 Owner: Tony Elliman & Lorna Lines

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Revision History

Version	Date	Amended	Reason
V0.1	30/5/2010		Initial draft
V1.0	15/6/2010	Wording changes and additional explanation for guidelines 2, 4, 12, 15, 17, 19, 22, section 5 and app. A	First release

1. Introduction

The purpose of this document is to provide a briefing for those developing accessibility standards and related guidelines. In particular it is aimed at the W3C WAI-AGE[1] initiative and the WCAG 2.0 recommendations[2].

The aim of the DIADEM project [EU: 034106] was to produce an assistive web-based technology to enable older people with cognitive declines to confidently and successfully interact with online forms. This technology is aimed at allowing people to remain active and independent members of society for a longer period of time. DIADEM provides assistive technology that extends a web-browser's capabilities by monitoring the ability of the user to interact with an online form system. This assistive technology can dynamically personalise the interface and offer optimised assistance to the cognitively disabled user.

The DIADEM project looked at two relatively unexplored aspects of assistive technology within the eInclusion agenda. First it tackled the cognitive declines of later life (see Appendix A for a more precise definition) and second it addressed the specific task of online data entry to obtain a good or service.

The WAI-AGE project already recognises the work of Lines *et al*. (2004, 2006 and 2007) and the DIADEM project is a continuation of that work. The project carried out an initial investigation with the target user group and then developed an experimental solution addressing their needs. This was put through two rounds of trials and refinement within the 40 month project (see Appendix B for a summary of the investigations).

In the course of these activities we have extended our knowledge of the impact of these cognitive declines and how web-sites and online technology can be adapted to support this user community. In this document we offer a set or recommendation and guidelines derived from this activity to the WAI initiative and the WAI-AGE project. It is also available as a public document for the eInclusion and web development community at large.

In the next two sections we present broad standardisation issues arising from out attempt to construct such technology. In the first case we question the current unit of standardisation "the form". This fails to focus on a unit of activity within the user's mind and we recommend that the standards framework needs to encompass a broader notion of "a transaction" to better address the user experience of interacting with systems online. Second (section 3) we address the issue of assistive technology architecture and the interaction between technologies. Most current technologies try to pick up the pieces after the form has been rendered rather than by dealing with it at a more abstract level and making rendering decisions to support a particular community. There is a need to look at assistive technology as an integral part of the standards for the web service delivery chain.

The document then addresses more specific guidelines that we have identified while working with the target population of users. These divide into two groups. The first (section 4) can be taken as design guidelines that can be applied to current static HTML form designs. However, an appropriate response to cognitive decline needs to reduce the cognitive burden of the data entry task. Some measures are context and data dependant so that they can only be applied dynamically during the process. These are addressed in the last section (5) before offering a general conclusion.

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[1] http://www.w3.org/WAI/WAI-AGE/
[2] http://www.w3.org/WAI/intro/wcag20

2. Forms and Transactions

The standards activity needs to address the terminology used to describe interaction with web based applications and services. The current terminology, in particular the notion of a form, focuses on units of transmission between the client and server agents. When discussing and designing for cognitively disabled users to access a web based service it is necessary to consider these users overall experience of the system in trying to gain access to some good or service. That process may involve several HTML "forms" and talking about the experience using a single form doesn't always address the overall experience.

The DIADEM project found it necessary to distinguish between the notions of a form (a block of data or questions grouped mainly for programmatic and transmission reasons) and a transaction (a block of data or questions grouped around user perceptions). For those familiar with Use Case driven development methods this roughly parallels the distinctions between a use-case and the steps within its interaction sequence.

From the perspective of an assistive technology developer there is a need to identify and deal with a transaction as a unit of activity. Such a notion of a transaction does not easily equate with web services which are also based around units of interaction between software components. A gap in the W3C standards portfolio appears to be a clear notion of a transaction and an ability to define and discuss transactions.

For example WCAG 2.0 guideline 3.3.4 – Error Prevention (Legal, Financial, Data) – uses rather tortuous language to identify the last or critical web page in a "transaction". It is also ambiguous about whether the references to "submissions" and "data" in the caveats are to the whole transaction or the data within the last web page.

To be fully effective in supporting a user, assistive technologies may need to identify the start and end of a complete transaction rather than just the part of that interaction defined in a single HTML form. The moves to Web 2.0 technology with concepts like AJAX force a rethinking of the notion of a form and moving to a notion of a transaction could also be constructive here.

2.1 Recommendation

In conjunction with the "FORMS" activities there is a need for an agreed definition of a transaction as:

> *A **transaction** is defined as a complete activity from the user's perspective. This represents their achieving a single goal or objective such as "to buy a railway ticket", "to request a certificate", "to amend their next of kin" or "to request equipment or adaptations to your home". This is a basic unit of service that must be specified by an application and delivered to a user via a user agent.*

It is also recommended that W2C consider whether it would be appropriate to develop a abstract transaction definition model that may be implemented with one or more HTML forms or XFORMS. For example DIADEM constructs a detailed model around the premise:

> *The abstract transaction definition will specify a set of individual data **items** that require, or may require, a response from the user in order to complete the transaction. Each item consists of a nominal **question** and one or more data entry **fields** with an associated **data type** for the combined set of fields. For example a date entry might have separate day, month and year textboxes but it is a single item with the data-type "date".*

3. Multiple Assistive Technologies and AJAX

Elderly users face multiple problems and may make use of several assistive technologies. A satisfactory experience when completing online forms may depend upon the use of multiple technologies which have to operate without interfering with each other. The current the web service delivery chain appears to be moving to make this more difficult to achieve.

This is a relatively simple proposition with HTML 4.0 forms and server based information processing. The user agent's response to well formed HTML is precise and predictable. Most user agents include scripting capabilities and assistive technology can be incorporated either as plug-in scripts or as tools operating at the device level in the operating system (OS).

However, applications and services are making greater use of user agent scripts (AJAX technology) and frameworks like the Microsoft .NET environment or Java Applets that pre-suppose the capability to download executable code into the browser. In this context any assistive technology other than intervention at the OS device level is fraught with problems.

To address cognitive problems the assistive technology must address the interaction as a whole. One consequence of this is the need for a transaction based model (above) and the other is the need to intervene at a much higher level than the OS device layer. Indeed the experimental trails with DIADEM made significant use of AJAX technology to achieve the desired experience.

3.1 Recommendation

The WAI initiative needs to consider the web's online service delivery chain (Figure 1) and the role standards might need to play in supporting the use of assistive technologies within the chain rather than just at the OS device level.

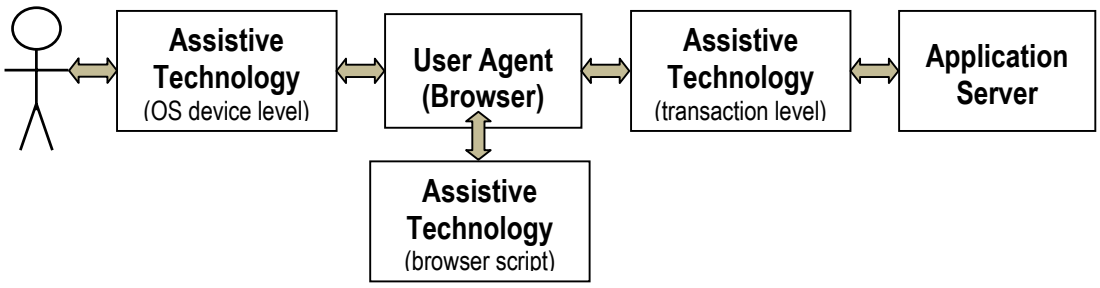

Figure 1: Assistive technology in online service delivery chain

Interaction between multiple technologies also needs to be considered within this context. For example screen reader technology interacts with the User Agent or OS device level on the assumption that there is no other audio output of speech. If, as in the case of DIADEM, a transaction level intervention makes direct use of speech is an integral part of the support (see guidelines 10 and 22) the two components can interfere badly.

4. Web Form Design Guidelines

This section presents guidelines that can be applied to the static transaction and form design when developing web-based interactive components for elderly or cognitively impaired users. They are considerations that apply to any form or screen design environment including simple HTML 4.0 forms.

4.1 Overall Presentation of a Transaction

This first group of guidelines addresses the overall experience, layout and presentation of a transaction. They have origins in the literature reviewed at the start of the project but were repeatedly re-enforced by the target user groups at every stage of the project. Initial dialogue with users reported negative experiences related to lack of consistency, visual clutter and difficulties with the navigational interface. In both experimental rounds users welcomed the simplicity and consistency provided by DIADEM.

The ability to maintain attention and awareness of context, in the presence of reductions in perception and processing capabilities, are aided by designs which minimise distractions and reduce the overall cognitive work load processing the information on the screen and making appropriate responses.

4.1.1 Guideline 1: Be consistent

Maintain the consistency of the experience (not just the presentation). This applies both within a single form and web-site but also across different sites and type of transaction. Use standard widgets and components and follow the accepted conventions within the market sector.

4.1.2 Guideline 2: Vertical scrolling and page navigation

Use multiple pages to minimise or avoid scrolling. The navigation structure of the forms should be logical and clear.

It is critical that the end-user always knows where they are within a transaction, how much has been completed and how much of the data entry task remains. In discussions with users complex navigation structures were identified as a core frustration point and a key reason for not completing a task. In particular scrolling pages longer than the screen caused problems – any need to be aware of unseen information creates a short term memory demand.

In our trials the preferred method of page navigation emerged as wizard like “Next” and “Previous” buttons that remain visible in a fixed position at the foot of the screen.

4.1.3 Guideline 3: Keep pages simple and avoid clutter

Keep the page structure simple and avoid clutter. Use a single data entry column working down the page.

Elderly users are easily distracted and tend to process data in a more linear fusion. Observed behaviour during the DIADEM trials showed users reading everything, for fear of missing something, and several also tended to read systematically down a column (news paper style). They tended to miss horizontal links and, by reading everything, got confused about what to do next.

4.1.4 Guideline 4: Use expected sequences for questions

When requiring users to provide standard information such as current address, ensure that this information is requested using a commonly expected sequence of questions.

Unexpected sequences effectively interrupt the train of thought raising the cognitive work load. With limited processing and problem solving capabilities re-orientation to the context becomes problematic. Short term memory problems may also exacerbate the problem.

This guideline needs to be addressed with care. In our trials something as apparently trivial as asking for house name before house number caused significant comment from users about the illogicality of the sequence.

4.1.5 Guideline 5: Clearly distinguish headings and sections

Render headings and sections in ways that are distinct from other text so that they can be clearly identified. For example by using bold face and a larger font size than the rest of the text.

This adds to the guidance under 1.4 in WCAG 2.0 by going beyond a simple visual perception problem and recognising that this important to orientation in the data entry task.

4.1.6 Guideline 6: Include a plain black and white option

Make it possible to select a black and white or minimum colour scheme.

This recognises the issue that for some in this user group colour is interesting but not necessary. With reduced visual acuity high contrast and perception of the text takes priority. This adds to the guidance under 1.4 in WCAG 2.0.

4.2 Supportive Elements in a Transaction

In a addition to the direct questions or prompts for data, a form or transaction can contain a large number of text elements that we can loosely describe as supportive information. This next group of guidelines deals with the provision of such information

4.2.1 Guideline 7: Provide clear complete instructions

Provide a complete set of instructions at the beginning of the transaction. It should be easy for the user to recall these to the screen at any time. If additional information may be required include list of all information (such as bank account details) or documents that will be required. If there are also specific instructions for some sections of a form the format should be distinct (for example a different background colour).

This serves two purposes it helps the user orient themselves to the task at the beginning and ensures that they won't be distracted from the process by having to go and find odd bits of information during the task. With reduced attention and short term memory capacity such a diversion can lead to the task being effectively abandoned.

4.2.2 Guideline 8: Allay security and confidentiality fears

Recognise and allay security fears when asking for personal or sensitive data. Explicitly provide assurances to the user within the form, explaining how the information provided by them would be stored, and who will have access to it. Minimise or eliminate the need for the server site to maintain profile data that includes sensitive information about users.

The theme of security and trust is documented in the literature but it emerged repeatedly from this target group during the interviews and system trials. Users seemed sceptical about donating personal information in electronic format which could then be stored and

potentially used against them. They voiced concerns about who had access to their information once it had been stored. Explicit reassurances are needed as part of the transaction presentation – a link hidden in the fine print at the end of a page is not accessible enough to have the desired effect.

4.2.3 Guideline 9: Provide help desk support

Provide a way to contact a real human helper.

A very clear message from the majority of users interviewed at the start of the project was the requirement for direct support, preferably face to face. This was re-enforced in the trials. When the user is experiencing problems the reassurance of a human voice on the phone or a person providing local assistance allays the anxiety. On the other hand increased anxiety generates a vicious circle that further reduces problem solving capabilities.

This guideline calls for a level of real-time help that is generally not available to the population at large when completing online forms. However, this highly personalised type of assistance provides direct support for all four of this target group's cognitive impairments outlined in Appendix A.

4.2.4 Guideline 10: Add recorded speech

Add recorded speech linked to the text element of the transaction.

The trial responses from some users showed that even those who are not sight impaired to a degree where they would use a screen reader find it useful to have audio speech prompts. Both hearing and reading the question helped to clarify what the question was asking for.

4.2.5 Guideline 11: Clearly identify mandatory responses

Mandatory fields should be presented in a consistent format that distinguishes them from non-mandatory fields.

The common convention of small asterisks is hard to perceive and there is no agreement about where it is placed or the colour used. This guideline benefits all users but here again reducing the cognitive load by making this distinction more obvious is more critical for the target group.

4.2.6 Guideline 12: Hint and help message ubiquity

If automatically displayed hint or help messages (for example tool tip text) appear on any field they should be present for every input item. The presentation of this supporting text also needs to be clear, consistent and positioned so that it is naturally read before filling in the response.

Failure to do display extra support on some input items is confusing. When some items get explained and some do not, it can create the impression that the system is failing and induce anxiety. There is thus the danger that this small disruption in pattern can become a major distraction.

4.2.7 Guideline 13: Make error messages ubiquitous and specific

Avoid generic help messages or simply flagging fields containing an error. Provide specific information clearly linked to the relevant field for all detectable errors.

For example, instead of "You should fill in the field" customize the message to reflect the actual field needing completion: "You should fill in the surname". Even something like "You should fill in the field outlined in red" can too generic.

This adds to the guidance under 3.3.1 in WCAG 2.0 and suggests that it is not simply a matter of providing text as an alternative to colour or iconic indicators but that the more specific nature of a text message adds to the information from the icon or colour indicator. Generic indicators place the cognitive burden of working out what is wrong on a user who, in this case, may have reduce problem solving capabilities.

A failing of XFORMS is that it allows only one alert message for an item but different errors within the same item may need different content to respond specifically to the error.

4.3 Use of Specific Response Mechanisms

This last group of guidelines address problems with specific input widgets and data types. Some of these arise exclusively from the experience of users during the trial phase of the project.

4.3.1 Guideline 14: Avoid drop-down lists

Wherever possible, drop down lists should be avoided for this target user group. In some cases however, it is not practical to present information in any other way other than in drop down list format. As a rule of thumb don't use lists for 8 or less items – use radio buttons.

Some literature indicates that dropdown lists should be used in preference to radio buttons (Miller & Jarrett, 2001; Rowland, 2004), however, the experiences of elderly users in the trials with DIADEM strongly suggests the above guideline is correct. The rationale seems to be that having the options on view is preferable to the difficulties of selecting the drop down arrow and scanning the list.

4.3.2 Guideline 15: Use three input boxes for dates

Use the three input box format for dates supported bt a "standard" date chooser widget.

This avoids all the confusions of punctuation and field ordering. In trials with this user group considerably more accurate date information was captured and consistently provided in an appropriate format.

A difficulty in implementing this guideline is that currently available AJAX date chooser widgets but assume a single text field for date entry. There are also significant differences in format and functionality among the widgets available, and the establishment of a "standard" widget would significantly benefit this group.

4.3.3 Guideline 16: Avoid multiple line text boxes

Avoid the use of multiple line free text boxes wherever possible.

Again this emerged during trials with this user group. Multiple line boxes caused confusion about how to get to the next line because the return key behaviour has to be different from other text boxes and entry fields.

4.3.4 Guideline 17: Permit other responses

When none of the response options to a particular question are considered appropriate by the end-user, the end-user should have the opportunity to complete a text box.

The problem of not being able to find the answer in drop down lists or with radio buttons arose in the initial user investigations. The suggestion was that, at times, all of the options offered were apparently inappropriate and selecting just one of them did not make sense to the user.

At first sight adding extra text boxes to every selection type response seems to add clutter to the screen. However, these need only be presented where the user cannot make a selection (see guideline 23 below) and it is also possible to define a widget that allows the response to be typed in the selection area.

4.3.5 Guideline 18: Avoid requiring users to attach files

Avoid requiring users to attach documents, however if this absolutely necessary, provide the user with an alternative such as posting or faxing copies of the information.

This comes from focus groups with careers and asking about best practice but it was also supported in part of the second trial. Attaching or up loading documents is a complex technical process and it is almost impossible to avoid technical jargon about files and type. It may simply be too demanding for some of this group.

5. Web Form Behaviour Guidelines

Cognitive declines (and other physical declines) produce a need for the system to deliver additional help and support. However, they also reduce the ability to cope with large volumes of information and to maintain orientation in the presence of distractions.

Support needs to be targeted at the current user context. It is not enough to make static extensions to the transaction presentation as above. It requires dynamic behaviour which delivers support just in time for it to be effective. That is it relates to the user's likely current train of thought and doesn't inhibit them in their current activity.

The DIADEM project explored several areas of dynamic presentation to make what was visible on the screen context sensitive. In this case the context was based both on the user's situation, as indicated in their responses, and the point they have reached within the data entry process. Users gave a very positive response to this level of interactivity within the interface.

This section presents guidelines that should be applied to the dynamic behaviour of web forms when developing interactive components for elderly or cognitively impaired users. They are considerations that apply to what happens during the data entry process and are relevant to both AJAX technology components and responses from the server side.

Several issues here relate as much to the User Agent technology as the content and behaviour of a form.

5.1 Maintaining the Context

This first group of guidelines set out dynamic behaviour that help the user maintain their orientation within the data entry task.

5.1.1 Guideline 19: Completed and uncompleted questions

Questions that have been completed and those that remain to be completed should be presented in a contrasting style or colour that is easily distinguishable.

This reduces the cognitive burden of maintaining orientation within the data entry task and compensates for reductions in perception and processing capabilities. In our trials we greyed out the completed fields. Users found this intuitive and responded positively to this type of support.

5.1.2 Guideline 20: Emphasise the current cursor position

The question and required response in focus should be easily identifiable with a consistent indicator applicable to all response types.

In trials several users had problems with the size of the flashing I beam cursor commonly used in text fields. The provision of other, more easily perceived indications of the current question and answer field were found to be helpful.

5.1.3 Guideline 21: Field feedback should be "immediate"

Give feedback on fields with errors as soon as the user has completed the field. Note that the system should also identify mandatory fields that have not been completed as an error and request end-user input at an appropriate time.

If feedback is simply delayed to the end of the form it's too late, and the message can be ineffectual because the user is no longer thinking about this section or item on the form. This produces problems with users who have difficulty re-orienting themselves.

This is a complex problem because the simple alternative to check and flag errors whenever a field value changes can also have negative effects. This can cause the error indicators to flash on and off while typing or for mandatory fields to be flagged as missing before the user has got to the point of thinking about them. These are all distractions. Because they do not make sense to the user, they produce excessive cognitive demands trying to solve problems that, at least for the user, should not exist.

5.1.4 Guideline 22: Use non-intrusive ways to prompt users

Avoid the use of pop-up windows and taking the focus away from the current field. Provide help and support in ways that are non-intrusive and allow the user to continue the data entry process.

If support is provided pro-actively during the data entry process, so that it is at the right time, it must also be delivered in ways which are not intrusive. The use of pop-up windows or "lightbox" analogies to present a message to which the user must respond is highly distracting and blocks the user's ability to continue data entry. The effect is very disturbing in this user group. However, it is precisely the less able members of the group who will need more support and, for example, giving feedback on screen without disturbing the focus or cursor position is critical. Users responded well to DIADEM's solution which was to display such prompts in a reserved area at the top of the screen.

5.2 Avoiding Mistakes

A key element in avoiding incorrect data being submitted is to only ask for relevant information to be typed in. This further reduces the cognitive load, speeds up entry and improves the quality of data submitted. Although some reduction in demand can be achieved by careful transaction design some presentation decisions rest on previously entered data and have to be made as dynamic decisions. The following guidelines address these issues.

5.2.1 Guideline 23: Only present relevant questions

Only present the questions that need to be answered. Suppress presentation of questions which are redundant.

Online forms frequently contain sections which are only to be answered if certain conditions are true. Not asking the irrelevant questions not only speeds up the process and avoids capturing spurious answers but it also avoids distractions. In some cases it can avoid more distressing consequences for the user, for example not asking a widow questions about both her and her spouse.

5.2.2 Guideline 24: Pre-fill fields with known data

Where known (or likely) data is available pre-fill response fields with this data. Note pre-filling a field doesn't mean the user cannot change it and the user should be allowed to edit the field.

In our trials users were very positive about the pre-fill function offered. They commented that it saved them time and effort, in terms of having to identify what information was needed and then type this information into the appropriate input fields.

5.2.3 Guideline 25: Auto-fill fields with inferred values

Where field values can be inferred from earlier answers auto-fill this information but allow the user to edit it.

Again in our trials users found this feature very useful, in terms of providing a less confusing interface, which saved them time.

5.2.4 Guideline 26: Tolerate and remove redundant spaces

Fields where users might add or insert spaces when typing naturally should not be highlighted as containing errors. For example dates and telephone numbers.

Presenting these to the user as an error is confusing because the information looks right. Locating an additional space within such a field is an extremely difficult task, even when the problem is understood and the user is explicitly looking for errors.

5.2.5 Guideline 27: Provide auto-capitalisation

Where the rules are known, provide automatic capitalisation of letters.

This logic would apply to initial capitalisation to fields such as personal names or street names and full field capitalization to fields such as alpha-numeric postcodes. This is a simple extension of the previous guideline addressing redundant spaces.

Ideally applications should be tolerant of such variations in input but client end error checking and possibly post processing by the user agent can achieve the same effect.

5.3 Specific Input Element Issues

During the DIADEM project a few issues arose around the user agent and input element behaviour which don't neatly fall into one of the above categories. These are addressed here.

5.3.1 Guideline 28: Button click sensitivity

Ensure double clicks don't simultaneously set and reset buttons.

During trials we found users trying to double click check buttons because they expect this to select the element or effect a single change. In the case of things like check boxes this produces a double event setting and then clearing the selection. The unexpected behaviour then becomes a problem to be solved.

More consistent user agent behaviour, from the end-user's perspective, is needed in response to clicks, double clicks, tabs and the return key across all types of input element.

5.3.2 Guideline 29: Field and button size and spacing

Radio buttons and field sizes should resize, along with increased sensitive areas around them, to be consistent with the label font size changes. The increased size should be accompanied by increased spacing (to reduce the likelihood of incorrect selections).

Forms are not just readable text so font scaling alone is not an adequate response to visual impairment. In the use of pointing devices there is the need to address fine motor co-ordination problems both as in their own right and as an adjunct to the visual impairment.

In our trial scenarios users struggled to move between input fields even when font size increases were applied. The use CSS and AJAX technology to map font size changes into appropriate rescaling of all input elements showed improved performance but it was also clear that creating a larger sensitive area around the control could also be more effective.

6. Conclusion

The DIADEM project looked at two relatively unexplored aspects of assistive technology within the eInclusion agenda. First it tackled the cognitive declines of later life and second it addressed the task of online data entry.

The web is not alone in confronting the older end of our population with technology they have difficulty handling. As a whole, society has moved to become cognitively more challenging in the use of mobile phones, set-top-boxes in-car electronics and so on. Perhaps the resistance of elderly users is not just conservatism but recognition that they have real cognitive limitations inhibiting their ability to use such technology.

Some key lessons emerge from the initial investigations and trails with the DIADEM solution:

- Consistency,
- Simplicity,
- Avoiding distractions, and
- Avoiding the unexpected.

However, the guidelines we have established above become incorporated in to the wider Web Accessibility Initiative, it is important not to lose sight of these key principles behind them.

Appendix A. Defining Cognitive Decline

Addressing the technological needs of the cognitively disabled is an inherently complex activity (see Boham & Anderson, 2005), which is exacerbated by the complexity and range of cognitive disabilities. DIADEM only aimed to address part of this spectrum. The intention was to deal with the cognitive declines that come with age rather than inherent or acute cognitive limitations. These declines, sometimes referred to as mild cognitive impairment (MCI), emerge slowly over many years. There is no clear point at which the person becomes "disabled".

In trying to define those cognitive declines that are likely to impact the individual's ability to interact with Internet technologies, Rowland (2004) makes the distinction between clinical cognitive disabilities and functional cognitive disabilities. The category of clinical cognitive disability comprises learning disabilities, attention disorders, genetic or developmental disabilities, congenital birth defects and neurological impairments (see Boham & Anderson, 2005; Rowland, 2004). The clinical diagnosis of cognitive disability is important from a social, welfare and educational perspective so that the appropriate support for a particular cognitive disability can be offered. However, when guiding internet technology designers, a definition of cognitive disability based on cognitive function (rather than clinical condition) may be more useful (Boham & Anderson, 2004).

Functional cognitive declines can be considered as the output of the clinical cognitive conditions and may directly affect interaction with Internet technologies. Rowland (2004) classifies these functional cognitive declines as:

- perception and processing,
- memory,
- problem solving, and
- attention.

Each of these areas of functional declines is discussed further in the following sections.

A.1 Perception and Processing Declines

A decline in perception and processing impacts the individual's ability to identify, perceive and integrate information in order to make sense of the world around them. Interacting with Internet technologies is likely to be negatively impacted by such perception and processing declines. A typical web page presents a large amount of information, all of which must be processed for the user to make an accurate judgement of where they are and what they should do. Text, graphics, colour, interaction prompts (such as hyperlinks, buttons, scroll bars) etc. must first be perceived and then processed for the user to make sense of the information presented. Declines in the ability to perceive and process the information will likely lead to user experiencing difficulties and frustration with the web page and may ultimately lead to discontinued use.

A.2 Memory Declines

Declines in any or all of the well-established categories of long term, short term and working memory are also likely to impact the cognitively disabled users' ability to interact with internet technologies appropriately. Memory declines are likely to be exacerbated by poor web page navigation structures (Rowland, 2004) that do not support the user in identifying where they have been, where they are and where they must go next. Feeling 'lost' or confused within a website is, once again likely to lead to the end user becoming frustrated with the website and may lead to discontinued use.

A.3 Problem Solving Declines

A decline in problem solving ability is likely to impact the users' ability to understand why, for example, a hyperlink fails to take them to the expected web page. Furthermore, the ability to identify corrective action, such as following an alternative navigation route, may also be impaired as a product of problem solving declines. Again, a negative end user experience and the reluctance, perhaps, to revisit the website or use the internet, is the likely output of such a scenario.

A.4 Attention Declines

A decline in the ability to attend to information presented within a website or web page, is likely to negatively impact the users' ability to successfully complete their web activity. For example, a user who is seeking information may be distracted by moving graphics that surround the text that they are attempting to cognitively process. When acquiring goods or services, attention declines may result in the task being abandoned should it become too cognitively demanding, for example too much information must be perceived and processed or increased demands on memory are made by a complicated navigation structure.

Appendix B. DIADEM Project Activities

To achieve its objectives the DIADEM under took three major phases of activity each of which has contributed to the recommendations and guidelines within this document.

- The initial activity researched the area in detail and developed the specific requirements and architecture for the overall DIADEM system. A critical part of that work involved structured interviews, the completion of existing web forms and focus groups with both the elderly populations and experts from support groups.
- The second phase involved the development of an experimental system and field trials targeted at exploring possible support strategies and refinement of the system design.
- In the last phase a revised DIADEM system was subjected to a more rigorous evaluation aimed at proving the value of the concepts it embodies. This involved further trial sessions with elderly users and a comparative evaluation of the DIADEM system against the current versions of online forms.

This work programme spanned 40 months and covered parallel activity with users in the UK, Norway and Italy.

B.1 First Phase – Initial Research

This stage of the investigation involved both key-stakeholder focus groups and end-user investigations that were designed to elicit the core functional requirements of the DIADEM system. The aim for both activities was to identify social and technological barriers; to identify the basic functionality as of end-user interaction needs, and to identify the design features that might support end-user interaction with online forms.

The key-stakeholder focus groups in each country comprised 5 – 12 representatives from government agencies, local government and private care agencies and charities that support the elderly. Each session was structured around a short agenda and lasted approximately 1.5 hours. During the session, data was recorded for subsequent analysis following the thematic method as described in Braun and Clarke (2006). The findings from each country were combined using the Freemind software to create a mind map as a visual representation of the overall results[3].

In addition to the focus groups, elderly users participated in trials with existing online forms and follow up interviews. In total 80 participants took part in these trials. During these trials, end-users were asked to use a number of online forms and comment on their experience. To test whether we were accessing people with cognitive declines each user was assessed using the widely accepted Mini-Mental State Examination MMSE as part of the interview.

As a result, of these activities the system requirements identified the ambiguity between forms and transactions (section 2 above) together with 18 (almost two thirds) of the guidelines.

B.2 Second Phase – Exploratory Evaluation

The primary objective in these trials was to understand users' reactions to DIADEM version one, and thereby identify requirements that could be fed into the development of the

[3] The 'Freemind' software is available from URL: http://freemind.sourceforge.net/wiki/index.php/Main_Page

DIADEM version two. Thus the approach to data collection and analysis in this stage was underpinned by an interpretive epistemology aimed at uncovering explanations.

The procedure followed was similar to the initial trials with existing online forms but in this case users followed a think aloud protocol using the DIADEM system to complete the online form. The subsequent interview elicited further information about the experience and conducted an ACE-R[4] test of cognitive ability (Mioshi et al. 2006) and a SUMI test of usability (Kirakowski & Corbett, 1993).

User selection was also made stricter to increase the number of users with potential declines. Selected users had to meet at least one of the following criteria:

- Aged 70 or over.
- Self-reported difference in memory or cognitive functioning and no more than 12 years in full-time education.
- Scores more than one standard deviation below average on at least one of the ACE-R sub-scales.

As a result, 39 females, 38 males with an average age 67.8 years were included in the trials. Even at this very experimental stage the SUMI data showed that the target user group responded more positively to the interaction based on the guidelines than the average population responses in the SUMI organisation data bases.

This phase identified 8 more of the guidelines above and led to the endorsement and refinement of several others. The performance of the experimental software also highlighted the weaknesses of the forms model and highlighted the need for a transaction based model as discussed in section 2 above.

B.3 Third Phase – Confirmatory Evaluation

End-user trials in this last phase focused on showing how DIADEM version two delivered benefits first to the elderly user and, in consequence, represented a benefit to the application or service provider. Thus the approach to data collection and analysis shifted to a positivist epistemology aimed at uncovering evidence of a change for the good.

For these trials data was collected from the user's interactions with legacy online forms and completing the DIADEM support process 7 to 12 days later. To avoid ordering effects the sequence was randomised. SUMI data was collected for both experiences and users were asked to compare the two approaches during the interview stage.

This activity used the same selection criteria as the second phase and in total 90 users took part spread evenly across all three countries. The SUMI data showed the experience with DIADEM to be significantly better than with the legacy forms and users were positive about many aspects of the software.

Other activities at this stage included evaluation of the system with other assistive technologies and experiments with some typical commercial applications to explore some issues identified in earlier parts of the project.

This phase identified the last 3 guidelines and highlighted the issues about interacting assistive technologies discussed in section 3 above. User responses also endorsed many of the other guidelines.

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[4] The Addenbrooke's cognitive examination (ACE-R) was in place of the MMSE because the initial research showed the MMSE to lack sufficient sensitivity to mild cognitive decline.

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