

## The effect of cue media on recollections

***Citation for published version (APA):***

Hoven, van den, E. A. W. H., & Eggen, J. H. (2009). The effect of cue media on recollections. *Human Technology : an International Journal on Humans in ICT Environments*, 5(1), 47-67.

***Document status and date:***

Published: 01/01/2009

***Document Version:***

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

***Please check the document version of this publication:***

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

***General rights***

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

***Take down policy***

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

## THE EFFECT OF CUE MEDIA ON RECOLLECTIONS

Elise van den Hoven  
*Industrial Design Department  
Eindhoven University of Technology  
The Netherlands*

Berry Eggen  
*Industrial Design Department  
Eindhoven University of Technology  
The Netherlands*

**Abstract:** *External cognition concerns knowledge that is embedded in our everyday lives and environment. One type of knowledge is memories, recollections of events that occurred in the past. So how do we remember them? One way this can be done is through cuing and reconstructing. These cues can be internal, in our minds, or in our everyday environment. In this paper we look at memory cues in our environment by comparing the effect of cue modality (odor, physical artifact, photo, sound, and video) on the number of memory details people had from a unique one-day real-life event. Contrary to expectation, the no-cue condition (in effect, only a question asking the participants to write down their memories) created on average significantly more memory-details than the cued conditions.*

**Keywords:** *external cognition, memory cuing, autobiographical memory, augmented memory system.*

### INTRODUCTION

*Autotopography* (González, 1995) studies personal collections of physical artifacts that serve as a memory landscape to the owner. These artifacts, such as photos, souvenirs, furniture, or jewelry, physically shape an autobiography because they link to memories that are important to the owner. Since those memories are important to the owner, the artifacts that link to them are also important; however, this link of significance is often imperceptible and unknown to other people. A collection of artifacts, its arrangement (such as a home altar), and its location (stored in the attic or placed in the middle of the living room) represent a part of the owner's memory, history, and thus identity (Cohen, 1996). At the same time, these artifacts might represent desire, identification, and social relations, and therefore establish a form of self-representation.

A concept related to autotopography is called distributed cognition (Hollan, Hutchins, & Kirsh, 2000; Hutchins, 1995; Perry, 2003; Rogers, 1997), which also studies the interaction between the physical world and human cognitive processes. *Distributed cognition* (Dcog) represents a system of activity that includes all relevant components of an activity, such as the people, the interaction between people, the media used, and the environment within which

the activity takes place, including tools and artifacts. Dcog is a new and not yet well-defined framework for understanding human activity that arose from the idea that cognition is not limited to within the heads of people (internal cognition), but can also be brought into the real world (external cognition) of physical artifacts and their surroundings. *External cognition* was first coined in the context of graphical representations by Scaife and Rogers (1996) and, in a broader view, serves three functions (Preece, Rogers, & Sharp, 2002): (a) to simplify cognitive effort by using tools to compute for the individual, (b) to annotate and use cognitive tracing, such as writing shopping lists to support remembering or reshuffling the playing cards in your hand to see new game opportunities, and (c) to reduce memory load, for example, by using reminders or memory cues. Hollan et al. (2000) distinguish three types of distribution of cognitive processes: (a) distributed over members of a social group, (b) distributed over time, where earlier events influence later ones, and (c) involving coordination between internal and external (material/environmental) structures. One aspect of the latter type is the way external artifacts can be used to cue internal memory reconstruction, which is the focus of this paper.

Most of the Dcog research to date has been applied to collaborative and work environments. Therefore, a challenge for this field is to take the research outside the office into, for example, the home. In-home recollecting, which also involves cognition, people and physical artifacts, is the foundation of the experiment in this paper on the effect of different memory cues on memory recollections.

The autotopography and Dcog frameworks show that HCI specialists or interaction designers cannot focus simply on the interaction at hand: all related fields of the design-to-be must be studied. Therefore, when we had the opportunity to design a system that would support everyday recollecting, we started with a domain specialization into (autobiographical) memory by extensively researching the literature, terminology, and practices to pinpoint the key traditions within the field (Hoven & Eggen, 2005a; Hoven, Eggen, & Wessel, 2003). One of many things we learned from the field of autobiographical memory is that physical artifacts cannot “contain” memories but can serve as memory cues (for more information, see Hoven & Eggen, 2008), which is one means to retrieve memories. A cue (or trigger) is a stimulus that can help someone to retrieve information from long-term memory, but only if this cue is related to the to-be-retrieved memory. Anything and any type of information (spoken word, color, action, or person) could be a cue, as long as there is a link between the cue and the to-be-remembered event. Therefore, in this paper we look at what type of available media, specifically, photos, videos, sounds, smells, or physical artifacts, is most effective in cuing memories. Because our research background is in interaction design, we found it obvious that this should be tested in context. So-called real-life studies are not as straightforward as is typical in the autobiographical memory field, where memory is tested mainly with students under lab conditions. The following experiment, with accompanying literature overview and method development, will show that cognition definitely did not end as a source of information for interaction design, because we used and studied memory in order to inform the design of an interactive system (see Hoven & Eggen, 2008, for an overview of autobiographical memory theory resulting in design recommendations).

## MEMORY CUING EXPERIMENT

Many people will recognize how browsing through a stack of old photos or revisiting childhood places brings back memories that may have not been thought of for many years. Indeed, a meta-analysis of the literature on context-dependent memory by Smith and Vela (2001) shows that, on average, reinstating a context has a beneficial effect on memory. This phenomenon is usually described in terms of the encoding-specificity principle (Tulving, 1983), which states that the probability of recall increases to the extent that environmental cues match the information that is stored in memory. Such a memory-enhancing cue may contain “item, associative, and/or contextual information that is encoded in the memory trace” (Smith & Vela, 2001, p. 206), and the process of recollection triggered by such cues is typically experienced as relatively involuntary and automatic (i.e., associative retrieval, Moscovitch, 1995; Schacter, 1996; or direct retrieval, Conway & Pleydell-Pearce, 2000).

Many previous studies on context dependency relied on college student samples, employing non-word letter combinations in laboratory settings (e.g., Chu & Downes, 2002; Rubin, Groth, & Goldsmith, 1984; Vaidya & Gabrieli, 2000). The question rises whether such results may be generalized towards everyday recollection. Only a limited number of studies examined the effect of real-life cues on autobiographical memory. In an influential case study, Wagenaar (1986) used only text as cue. He kept a diary of remarkable events happening each day over 6 years. More specifically, Wagenaar recorded for each event what happened, where, when it happened, and who was present. Later he tested which category of information was most efficient in cuing the complete set of information. He found that the “what” information was most helpful in retrieving the other categories, especially when followed by “when” information. However, the presentation of “when” information alone appeared quite useless.

Burt, Mitchell, Raggatt, Jones, and Cowan (1995) aimed at extending Wagenaar’s findings by employing photographs as cues. The photos contained various combinations of what, where, and who information (activity, location, and participants, respectively). The authors concluded that the uniqueness of a cue determined, at least partly, its efficiency for retrieval (in terms of recall delays). Activity cues rendered the shortest and participant cues elicited the longest recall delays. Taken together, presenting people with information about what happened benefits memory recall better than any other information.

Another particularly effective cue for facilitating direct retrieval is odor. The phenomenon that odors quickly bring back memories has been dubbed Proustian memory (see, e.g., Chu & Downes, 2002), following novelist Marcel Proust’s description of how smelling a Madeleine biscuit dipped in tea resulted in the sudden emergence of a powerful childhood memory. This Proustian phenomenon has found support in several laboratory studies (see Chu & Downes, 2002, for a short overview). Likewise, odors seem to facilitate autobiographical memory in a number of different ways. Rubin et al. (1984) presented participants with an odor, a verbal label, or a photograph corresponding to 16 common artifacts (e.g., baby powder, banana, peanuts, coffee, and cigarettes). After the cue presentation, participants had to describe the memory that it evoked and rate various qualities of that memory (e.g., vividness, emotionality, and rehearsal, the latter representing thoughts recalled or spoken of in the past). Although memories brought about by different cues were similar in terms of vividness and emotionality, odor-evoked memories were less rehearsed

than memories cued by verbal labels and photos. In a more recent cross-modality cuing study, Herz and Schooler (2002) found that odor-cued autobiographical memories were rated as more emotional than memories triggered by visual and verbal label cues. In addition, odor tended to make participants feel more “brought back” to the original event. Thus, these results suggest that odor-evoked memories differ from memories triggered by other cues with respect to subjective qualities (i.e., sense of reliving).

## Rationale for the Experiment

Various studies have investigated augmented memory systems (e.g., Balabanović, Chu, & Wolff, 2000; Frohlich & Murphy, 2000; Glos & Cassell, 1997; Piernot, Felciano, Stancel, Marsh, & Yvon, 1995; Shen, Lesh, & Vernier, 2003; Stevens, Abowd, Truong, & Vollmer, 2003), but the majority focused on “recording” memories (e.g., Bush, 1945; Clarkson, Mase, & Pentland, 2001; Fleck et al., 2002; Gemmell, Bell, Lueder, Drucker, & Wong, 2002; Ikei, Hirose, Hirota, & Hirose, 2003; Lamming & Flynn, 1994,) rather than on “retrieving.” Some studies focused on “searching” and “finding” previously recorded information (e.g., Starner et al., 1997), which is not the same as retrieving memories. No interaction design study known by the authors focused on personal memory retrieval or reconstruction (although work by Schütte, 1998, and Harman, 2001, is related) done by means of cuing. Therefore, this is the focus of the experiment presented in this paper.

In addition to odor, photo, and artifact cue types, we included audio and video cues. The reason behind this decision originates from the industrial context in which this research took place. This study was part of a larger research project (Hoven, 2004; Hoven & Eggen, 2003) aiming at designing a future augmented memory system for in-home use through which a user can support his or her personal recollection process, that is, to help remembering past events. The cues employed in the present paper are expected to be available to users for recording and playing back from such a device in the near future. In addition, these modalities represent all the categories of media that have been addressed in prior augmented memory systems (Hoven & Eggen, 2008), and we have shown that these physical artifacts can be denoted as souvenirs, where the word *souvenir* means to remember (Hoven & Eggen, 2005b). As far as we know, there are no studies that *cued* autobiographical memory with audio or video. Our interest in which cue type generated the most memories or memory details, and therefore was most suitable to implement in an augmented memory system, resulted in the following research question: What is the effectiveness of the following five media types (artifact, picture, odor, sound, and video) on cuing 1-month old recollections of a real-life event?

## Real Experiences and Memories

Obviously, the content of the memories that are retrieved spontaneously in response to cues is not comparable between participants. A solution to this problem, suggested by Chu and Downes (2002), is to arrange a series of naturalistic or real-life events for participants to experience. There are a number of studies that examined memory for standardized naturalistic events. To begin with, Hudson and Fivush (1991) joined kindergarten children on a 2-hour class field trip to a museum of archaeology. The children engaged in tasks such as

digging for artifacts with archaeological tools and making clay models of the artifacts they found. Their memory was tested on the same day of the week, 6 weeks later, 1 year later, and 6 years later. After 6 weeks children had a good free recall of the event (i.e., to the posed question, “What happened when we went to the Jewish museum?”), but after 1 year, the children did not. However, when they were presented with photographs of their trip, 87% of the children retrieved a considerable number of additional details that could not be seen in the photos, even after 6 years. Pipe and Wilson (1994) took a somewhat different approach and studied autobiographical memories of pairs of children who took part in a magician’s act. One of the children had to observe (observer role) while the other child was taught to be the magician’s assistant (participant role). Ten days and 10 weeks later, the children were interviewed. The results show that action and artifact recall were facilitated by the presence of relevant cues (i.e., items relating to the magic tricks, e.g., a magic wand and magic gloves) but not by contextual cues (i.e., the same room, or items such as pink curtains and the magician’s hat). In a second study following a similar design, Gee and Pipe (1995) found that children in the participant role (participants), who were interviewed using artifacts, recalled more correct information than the participants without artifacts and the observers in any of the two conditions. Interestingly, the authors report that “objects did not simply encourage children to repeat more correct information in free recall; rather, objects prompted children to report information that had not previously been reported” (p. 751).

Finally, Aggleton and Waskett (1999) studied adults’ memory of a visit to a specific Viking-museum that included a fixed tour through several scenes with distinctive odors (burnt wood, apples, rubbish acrid, beef, fish market, rope/tar, and earthy). On average 6 years later, the participants filled in questionnaires about the various displays in the museum tour, regarding, for example, types of clothing and jewelry worn by the Vikings. Compared to a baseline no-odor condition, the presence of the original museum odors during testing rendered more correct information than the presence of other odors that had not been present during the original tour. Thus, in addition to evoking qualitatively different autobiographical memories (i.e., judgments of emotionality or sense of reliving; Herz & Schooler, 2002), odors seem to improve the recall of details of real-life events.

All in all, reminiscent of results of laboratory studies on context-dependent memory, studies on the effectiveness of retrieval cues on autobiographical memory suggest that offering reminders of the encoding context, such as artifacts, photographs, or smells, facilitates recall. However, the question rises as to what type of retrieval cue is most effective in terms of eliciting the most detailed recollection. The aim of the present study was to directly compare the detail of autobiographical memories triggered by retrieval cues of different modalities, specifically odors, physical artifacts, photos, audio, and video.

Because our interest was in the effect of different cuing types on autobiographical memory detail (i.e., the event memory was defined as one memory, the differences in cue types could only be found in the details of this memory), we devised a method to quantify the number of generated memory units based on the model of autobiographical memory proposed by Conway & Pleydell-Pearce (2000). They specified three basic levels of autobiographical knowledge, namely (a) life-time periods, usually spanning years, (b) general events, taking place over several days up to months and, (c) event-specific knowledge (ESK), where the event lasts seconds, minutes, or at most hours. Since the present study asked the participants to recall a unique one-day event, the analysis of their written accounts specifically focused on ESKs.

In sum, the present study aimed at comparing the effect of different cue types on autobiographical recall of a real-life situation. For that purpose, participants engaged in standardized activities during a visit to a history-themed park. One month later, their recall of those activities was tested, employing a photograph, artifact, odor, audio, or video cue.

## Experiment Method

### Participants

Participants were 34 employees or students at the Philips Research Laboratories Eindhoven or the Eindhoven University of Technology. They responded to e-mail and company newsletter announcements inviting people to take part in an outing to a historical theme park (Archeon; see below). In order to approach a true day out, participants were instructed to bring at least one person of the other gender (not necessarily their spouse), resulting in a total of 69 participants. One participant dropped out prior to a final testing session (due to insufficient knowledge of the Dutch language, which was a requirement for the participants since the study was conducted in Dutch) resulting in a total of 59 participants (28 men, 31 women) in the cue–no cue conditions and 9 participants in the control group (no cue–no cue condition), to check for order effects solely. Unless indicated otherwise, the data in this paper are from the 59 participants in the cue-no cue conditions. None of the 69 participants had visited the Archeon theme park before.

### Apparatus

The devices used during the test session (see below) were (a) Sennheiser HD 500 “fusion” headphones, (b) Philips AX 1001 portable CD-players, and (c) Philips NO. 21PV715/39, 21-inch BlackLine color TV-VCR combinations. The devices were provided for each participant individually in the appropriate cue conditions (sound and video cues).

### Materials

Free recall was tested by means of two questionnaires, each containing two questions. Each questionnaire asked for a complete and detailed description of the event “making felt” or “making a fibula,” activities that all participants engaged in during their visit to Archeon. Participants were encouraged to write down anything that came to mind related to the particular event and to use as much paper as required, without a time limitation. The second question asked for other memories that were not directly related to the initial question but that came up while answering the first question (associations). All participants had to complete both questionnaires, one for each activity and one with cue, the other one without. Activity and cue choice were counterbalanced across participants. A control group of participants ( $n = 9$ ) formed the no cue–no cue situation.

Five types of cues were used to aid recall for the condition groups. Two variants of each cue type were used, each referring to one of the two standardized events (making felt or a fibula). Cues were (a) the felt bracelet or the ancient-design copper-wire safety pin (fibula) handcrafted by the participants themselves during the event (artifact cues); (b) a 10 x 15 cm

color photo of one of the two activities, showing the activity, the location, and the participants (photo cues); (c) vanilla incense or olive-soap water in small jars with punctured lids (odor cues); (d) a 20-second audio clip from either event containing voices, activity-related sounds, and background noise, presented through a CD-player and headphones (sound cues), and (e) a 20-second color video clip from either activity (also showing the activity, the location, and the participants), presented through a TV, VCR and headphones (video cues). The cues were specific for each tour group, meaning that the artifact, photo, audio, or video used as cues during the questionnaire phase were the result of that participant's group experience during the Archeon tour phase.

## Procedure

The study consisted of two phases. The first phase (Archeon visit) consisted of a trip to Archeon,<sup>1</sup> a history-themed park in the Netherlands. The architectural styles of the park's areas reflect various periods from the past (i.e., prehistory, Roman period, and the Middle Ages), thus creating a unique setting. The Archeon visit took place while the park was closed to other visitors. Throughout the day, every participant took part in five handcrafting activities, each lasting 20 minutes, at five different locations and explained by Archeon employees in historical costumes. The activities were (a) making a fibula by using a hammer, a pair of nippers, and a piece of wood, while the room was smelling of vanilla incense; (b) making felt by turning washed sheep's wool into felt while using olive soap, and knotting a felt bracelet; (c) making a candle by heating a wax plate between one's hands, rolling it up with a taper in the center, and finishing the edges; (d) making a rope with a special tool in which three thin ropes were twisted into one stronger rope, and (e) writing in calligraphy, using a feather and ink to write in a special ancient typeface, with excess ink removed with sand.

The participants were divided into small groups of 12 people, who participated in the activities in the fixed order described above, although each group started with a different activity. Two experimenters accompanied each group in order to videotape and take photographs of the activities, which would later be used as cues. At the end of the day, the experiment leader collected the handcrafted artifacts and explained to the participants that they would get the artifacts back after filling in questionnaires later. During the first phase, the memory-oriented character of the authors' research objectives was not mentioned to the participants.

The second phase of the study (test session) consisted of completing two questionnaires. Each questionnaire asked for recall of one of two standardized activities ("making a fibula" and "making felt"), selected after pilot testing of the activities and the questionnaires with two pilot participants at Archeon. Each participant completed a questionnaire for one of these activities in the presence of one of five recall cues (artifact; picture; odor; sound; video) of the corresponding situation (cue condition). The questionnaire for the other activity was completed in the absence of any recall cues (no-cue condition).

To approach a real-life situation, the participants were tested in the living room of HomeLab, a controlled laboratory environment closely resembling a three-bedroom house, located on the premises of the Philips Research Laboratories in Eindhoven. The participants were tested with the same cue condition in small groups (a maximum of five participants). Participants sat at a large living room table, adapted by means of wooden panels and headphones such that they could not see each other or perceive any cues from the others. In



the conditions involving audio, the participants were told to wear the headphones at all times and keep the volume level fixed, in order to prevent them from hearing other participants' cues. At the end of the session, participants were debriefed and received the artifacts that they had handcrafted during their Archeon visit.

## DATA CODING AND ANALYSIS

Comparing written accounts from different people describing their unique memories is not an easy task: Even if people participate in the same event, they can write about completely different topics or issues, depending on what they remember at that point in time. Comparing accounts quantitatively over different events is even more complicated. Still, developing a quantitative method for the analysis of written accounts is important for research on autobiographical memory, since it makes it possible to compare recollections from different people in different experimental conditions.

Most studies conducted to compare recollections from different people or different conditions focus on the validity of the memories, for instance, by asking questions about facts and checking whether the answers are "right" or "wrong" (e.g., Aggleton & Waskett, 1999; Gee & Pipe, 1995; Wagenaar, 1986). Other studies focus on aspects other than the content of the memories, for instance, the vividness or emotionality of the recollection (e.g., Herz & Schooler, 2002; Rubin et al., 1984).

For this paper, we explored six existing methods for the analysis of free recall accounts. They will be described in order of increasing complexity. The first coding procedure for autobiographical memory-cued recall is described by Chu and Downes (2002). They transcribed spoken responses and used single sentences as the unit of analysis. If sentences were long, they were split up into smaller units, when appropriate. Chu and Downes used a double-cuing methodology, which means that twice the participant was asked for free recall of a specific event, where the first time no cue was present and the second time a cue was present; Chu and Downes chose an odor. Later, the first free-recall accounts were used as a measure for verbosity, and for the second accounts the sentences were scored on the content being either old, meaning it was mentioned before, or new. The focus of this method was on a quantitative measure of the number of new sentences produced in 3 minutes of free-recall speech after the second cue, while checking the validity of the utterances.

The second method categorizes remarks. Pipe and Wilson (1994) asked children to freely recall a specific activity in which they had participated. After transcribing the interviews the statements were first checked for validity and later content-wise coded for "valid" categories, such as people, actions, artifacts, the context of the event, the accident (part of the activity the children took part in), and "error" categories, that is, distortions (based on actions that did occur but were changed), intrusions (based on actions that did not occur) and artifact errors. The same method was used by Murachver, Pipe, Gordon, Owens, and Fivush (1996) but with two additions: First, they added the category "generalizations," which was used when one utterance contained several actions or artifacts, and second, they checked whether the order of the utterances corresponded to the original order of the activity's events.

A more precise method, by Hudson and Fivush (1991), contained one additional coding rule compared to the previous two examples. That is, it started with the basic coding unit,

which they called a “proposition.” A proposition was defined as a statement containing an argument and a predicate. After the propositions were identified in the transcribed speech accounts, they were analyzed based on the content. The “valid” propositions were coded as either an act (action), description (of the environment), or elaboration (repetitions including supplementary information), and the “error” propositions as intrusions (based on actions that did not occur). Meanwhile, the free-recall account method by Brown and Kulik (1977) was the only method that involved participant-written free-recall accounts and did not involve checking for validity. Brown and Kulik studied personal shocks and flashbulb memories—vivid and detailed memories of dramatic world events, such as the 9/11 attacks—asking their participants to write down their free-recall accounts. They analyzed the stories by counting the total number of words as an objective measure on elaboration and by coding the content into the following categories: place, ongoing event, informant, affect on others, own affect, and aftermath.

Finally, Poole and White (1993) used syntactic units (SU) in their method for analyzing narrative responses. They defined an SU as the words that describe either an actor (he), an action (took), a direct object (a pen), physical traits (he is tall), qualifiers (he is not very tall), prepositional phrases (in the chair), temporal information (then), or they used quotes from the encoding event, where each of those categories is counted as a single unit. In addition to the category, the words were also marked as accurate, inaccurate, or uncertain. The interrater agreements for these three judgment categories were 84%, 81% and 87%, respectively.

The method described in our analysis, however, was developed to compare different free-recall accounts quantitatively, and therefore did not check any of the recall accounts for validity, thus making the error and generalization categories by Pipe and Wilson (1994), Murachver et al. (1996), and Hudson and Fivush (1991) superfluous. The content of the accounts was checked for the following categories: actions, objects, and context, as well as perceptions and reflections. The latter two types were included because, together, those five categories were assumed to cover the majority of utterances. Location was not used as a coding category because in this cuing study, location was part of the primary recall cue (“making felt at Archeon” or “making a fibula at Archeon”). The objective measure from Brown and Kulik (1977), which counts the total number of words per free recall, was incorporated in our method to have an objective measure of elaboration but, since this is rather straightforward, it will not be elaborated in this paper. In addition, our method drew on only the detail-level component of Poole and White’s (1993) SU method, although it is not based on content but rather on grammar. Our approach, then, makes it possible to quantitatively compare free-recall accounts of different events.

## **Analysis Method**

The objective of this study was to determine the influence of cues on recall of personal recollections in a social setting; therefore the validity of the recollections was not of interest. It is possible that a person recalling memories can consciously or unconsciously alter the truth but that is his/her responsibility. Because the method was intended to be objective and quantitative, it was decided not to interpret the contents of the written accounts but rather use a method based on grammar. In this specific situation, the texts were in Dutch and thus the method implemented Dutch grammar, but it is believed that the structure and background of the method would also hold for other languages. Participants’ accounts were made

anonymous and scored by two independent raters, who were trained for about 10 hours each on pilot experiment accounts.

With the intention to be able to quantify memories objectively in free-recall accounts, the specificity theory of Conway and Pleydell-Pearce (2000) was applied. This theory describes three hierarchical levels in autobiographical memory, namely: (a) lifetime periods, spanning years of one's life, (b) general events, which recur over a time span of days or months, and (c) event-specific knowledge (ESK), lasting seconds or at most hours. ESKs are the details in recollections, the lowest level of specificity, and thus suitable for counting free-recall accounts of a one-day unique event. We decided to make ESKs the starting point of the method, which consisted of three phases. The first phase concerned identifying an ESK, the second phase involved counting the details within the identified ESK, and the third phase categorized the general content of the ESK. Each sentence of the written accounts was analyzed according to the three phases.

The first phase of the method involved reading the sentence and checking whether it contained a description of a memory. If a sentence described something other than a memory, it was not an ESK and was removed from further analysis. For example, the statement "I am not so sure about that" refers to the previous sentence, but is no actual recollection. However, if the meaning of the statement was in doubt, the sentence was counted. The same held for repetitions: If two sentences were exactly the same and following each other, one of them was not counted. In the material evaluated, repetitions did not occur, and non-memory remarks were made in only a small number of cases. When a sentence contained a description of a memory, the method was implemented by identifying the ESK as the finite verb (*persoonsvorm* in Dutch), the accompanying subject (*onderwerp*) and direct or indirect object (*lijdend/oorzakelijk voorwerp* or *belanghebbend voorwerp*). This means that, in most cases, one ESK was represented by one sentence, although sometimes two sentences formed one ESK or one sentence formed two ESKs, depending on the number of finite verbs. Often a sentence with more than one ESK was easily recognized by conjunctions (*voegwoorden*). In the texts, ESKs were notated with square brackets (i.e., [ ]), making it possible to check the analyzed texts afterwards.

Since one ESK can contain many more details than another but is counted as one memory unit, it was decided to score each ESK on the number of ESK details. This was implemented in the second phase by counting the number of information-providing words. To facilitate this process, we developed a custom-made document containing a list of word-counting instructions and examples for diverse words and sentence structures. This document was given to the raters as a work of reference for the ESK-detail counting rules. We do not claim that this list is exhaustive nor in accord with linguistics standards; nevertheless, it was complete enough for the method described in this paper.

In short, this is the articulated process for counting ESK details<sup>2</sup> that we applied in our study. The finite verb (even if it was implied, which rarely occurred) and subject were always counted as one detail each. Articles were never counted and most other words were counted as one detail. There were some exceptions for the remaining words, though. In Dutch, compound, reflexive, progressive, and perfective verbs can consist of two words but were counted as one detail. Inchoative verbs can contain four words and were counted as two. Modal verbs were counted, whereas auxiliary verbs were not. Since diminutives, created by adding a few letters to the end of a noun, are often used in Dutch spoken language, and

therefore also in the accounts, they were not counted as extra details. In order for the method to be clear and not too complicated, it was decided that both coordinating and subordinating conjunctions were not counted. Relative pronouns were not counted when they referred to words in the same sentence (without adding information). On the other hand, when they referred to the previous sentence (which does add information), they were counted as one detail. Demonstrative adjectives and demonstrative pronouns were counted. Adverbs were counted as one detail and prenominal adverbs (junctions of several adverbs in Dutch) were counted as two details. Adjectives and nouns were usually counted as one detail unless the word was a junction of two information-adding words that could also be used as two separate words; these were counted as two details. The final category contained a number of expressions that could be replaced by one word and therefore had to be counted as one. The notation for the ESK details concerned cumulative numbers between angle brackets behind the word counted. For example, “[I <1> used <2> an old <3> hammer <4>.]” consists of 1 ESK and 4 ESK details.

In the third phase of the method, each ESK had to be categorized. The rationale for this step was to check for effects of cues on the general content of recollections, without interpreting the accounts or the validity. Based on suggestions by Martin Conway (personal communication, spring 2003), the following types were designated as useful descriptors of ESK information: (a) perceptual information, describing the senses, such as, “There was a strange smell in the room” (perception-specific knowledge, PSK); (b) reflection, opinion, or emotion-related information, such as “I was thinking to myself...” (reflection-specific knowledge, RSK); (c) state information on the situation or the environment, such as “The room looked ancient” (state-specific knowledge; SSK); (d) action information, such as “He bent the copper wire” (action-specific knowledge; ASK), and (e) object information, such as “The fibula consists of two parts” (object-specific knowledge; OSK). However two further issues complicated the outright application of these descriptors: First, some ESKs could contain more than one ESK type, and, second, the OSK was an exceptional case in this study (i.e., the foundation for the memory accounts was based on the activities of making felt or a fibula, thus biasing this type of ESK). To address these concerns, a hierarchical order was determined. Based on the analysis of the pilot test, we found that some ESKs were mentioned less frequently than others (e.g., the PSK was anticipated to be mentioned less often than the RSK). And, to prevent an OSK bias from influencing the results for the other knowledge types, the hierarchy was ordered based on an assumed increasing frequency, in which the raters first checked for a PSK, presumable the type with the lowest probability. If this ESK type was not found, the raters then checked for an RSK, then an SSK, followed by an ASK, and finally for an OSK. For the notation during the free-recall analysis, the identified knowledge types were written on the accounts above the corresponding ESK. In Table 1, a part of one of the coded accounts is shown as an example.

## Results of the Analysis Method

In order to calculate the interrater reliability for each of the three phases of the method, the two raters assessed all free-recall accounts from this study. For an overview on the descriptive statistics of an average account, see Table 2. This table shows that an average account contained 164 words, 18.5 ESKs, and 127.1 ESK details. These 18.5 ESKs can be subdivided into 0.5 PSKs, 1.6 RSKs, 3.9 SSKs, 11.3 ASKs and 1.2 OSKs.

**Table 1.** Example of Notations and Scoring for Event-Specific Knowledge.

Original Dutch Account	Text Translated into English	Notation Style in the Original Account	Scores
In het gebouwtje liepen we door naar achteren, waar we in een nogal rokerige en warme ruimte kwamen met een open haard.	We walked to the back of the building, where we came in quite a smoky and warm room with a fireplace.	[In <1> het gebouwtje <2> liepen <3> we <4> door <5> naar <6> achteren <7>], [waar we <1> in <2> een nogal <3> rokerige <4> en warme <5> ruimte <6> kwamen <7> met <8> een open <9> haard <10>].	ESK = 2 ESK-details = (7+10) 17 ESK-types = 2 ASKs words = 22

Note: An example of coded text, according to the method described in this paper (Column 1). In Column 2, the Dutch text is translated into English, in Column 3 the notation style is shown, and in the last column the total number of ESKs, ESK details, ESK types, and words counted in the text are given.

Interrater reliability was high for both the number of ESKs (Intraclass Correlation Coefficient,  $ICC = .97$ ) and the number of ESK details ( $ICC = .99$ ). Overall, ASKs were the most frequently identified ESK type in the free-call accounts. More information on this coding method is provided in Hoven (2004).

**Table 2.** Summary of Interrater Reliability.

	Average number <i>n</i> (min, max)	Interrater reliability
words	164 (22, 455)	N.A.
ESKs	18.5 (3, 50)	0.97
ESK details	127.1 (18, 340)	0.99
PSK	0.5 (0, 4)	0.78
RSK	1.6 (0, 9.5)	0.84
SSK	3.9 (0, 14.5)	0.76
ASK	11.3 (0, 28.5)	0.90
OSK	1.2 (0, 5.5)	0.49

Note: The average numbers per account (Column 2) and interrater reliability (Column 3) of ESKs (Row 2), the number of ESK details (Row 3), the numbers for each SK type (Rows 4-8), and the number of words (Row 1). The numbers between parentheses (in Column 2) show the minimum and maximum number counted.

## RESULTS OF THE MEMORY-CUING EXPERIMENT

Table 3 summarizes the results for the number of ESKs, number of ESK details, and associations (other memories that were not directly related to the initial event). In order to address the question of what cue type was most effective, the data were analyzed by means of

**Table 3.** Average Number of ESKs, ESK Details, and Associations for the Artifact, Photo, Odor, Sound, and Video Cue Groups Under No-Cue and Cue Conditions.

		<b>Artifact (n = 12)</b>	<b>Photo (n = 12)</b>	<b>Odor (n = 12)</b>	<b>Sound (n = 11)</b>	<b>Video (n = 12)</b>
ESK	No Cue	19.88 (7.35)	19.54 (9.36)	21.54 (9.93)	16.82 (8.26)	16.33 (12.94)
	Cue	15.33 (4.56)	17.54 (10.54)	19.67 (11.02)	15.55 (9.01)	17.33 (14.45)
ESK-details	No Cue	7.01 (0.81)	6.71 (1.22)	6.89 (0.81)	6.14 (0.96)	6.74 (1.18)
	Cue	7.07 (0.70)	6.59 (1.23)	7.16 (1.45)	6.82 (0.99)	6.55 (0.94)
Associations	No Cue	3.63 (2.59)	6.00 (3.25)	3.92 (4.36)	2.73 (1.85)	2.92 (2.70)
	Cue	5.04 (3.90)	4.13 (3.57)	2.88 (2.85)	3.18 (3.11)	3.83 (3.04)

Note: Standard deviations are in parentheses.

five (cue type: artifact, picture, odor, sound, video) x 2 (condition: cue vs. no-cue) ANOVAs with repeated measures on the last factor. The analyses of the number of ESKs and number of ESK details rendered rather similar results in that a significant main effect for condition emerged,  $F(1, 54) = 4.62, p < .05$ , and,  $F(1, 54) = 4.69, p < .05$  for number of ESKs and for number of ESK details, respectively. Contrary to expectation, however, cuing elicited lower numbers of ESKs and ESK details than the no-cue condition. For both analyses, the cue type by condition interaction remained non-significant,  $F(4, 54) = 1.22, p = .31$  and  $F(4, 54) = 1.78, p = .15$  for numbers of ESKs and ESK details, respectively. As for the number of associations, the 5 (cue type) x 2 (condition) repeated measures ANOVA did not show significant effects, all  $F$ s < 1.4.

The free-call recollections data was collected during a period of 29 to 43 days after the Archeon visit. On average, four participants per day completed the questionnaires, resulting in the latter participants recalling their Archeon visit a full 2 weeks later than the early participants. In order to see whether differences in delay affected the results, separate correlations between time since their Archeon visit and the total number of ESKs and association ESKs were calculated. Both correlations did not reach significance (ESK:  $r = -0.13, p = 0.28$ ; Association ESKs:  $r = -0.07, p = 0.58$ ).

## DISCUSSION

### Memory-Cuing Experiment

The goal of the present study was to explore which type of retrieval cue is most effective in eliciting details of autobiographical memories of a real-life event. In light of earlier findings, it

was expected that artifact and photo cues would generate more detailed memories (i.e., more ESKs of this event; see Gee & Pipe, 1995; Hudson & Fivush, 1991) than a no-cue (or text) situation, and that odor cues would generate more detailed memories than other cue modalities (see Aggleton & Waskett, 1999). However, the results show that no particular cue type elicited superior recall. Contrary to expectation, the absence rather than the presence of a retrieval cue-enhanced autobiographical recall in that more ESKs were reported. This finding is similar to the results of Chu and Downes (2002), who indicated that visual cues elicited fewer sentences than verbal cues. However, the present finding that, overall, fewer units of ESKs were reported in the cue condition is inconsistent with previous reports that recall is enhanced by the use of concrete cues (i.e., odor, Aggleton & Waskett, 1999; odor, Chu & Downes, 2002; photo & artifact, Hudson & Fivush, 1991; artifact, Gee & Pipe, 1995; Pipe & Wilson, 1994). How may this discrepancy be explained? One possibility is the use of different scoring methods. We devised a scoring method that was specifically aimed at quantifying ESKs (Conway & Pleydell-Pearce, 2000) and quantifying information-carrying words in these ESKs based on grammar instead of content. This method seems to deviate from other scoring methods and therefore makes it difficult to compare the results. The methods employed in previous studies categorized free-recall responses into (broad) categories (e.g., Brown & Kulik, 1977; Chu & Downes, 2002; Hudson & Fivush, 1991; Murachver et al., 1996; Pipe & Wilson, 1994), used answers on multiple choice items (e.g., Aggleton & Waskett, 1999), focused on validity (e.g., Aggleton & Waskett, 1999; Gee & Pipe, 1995; Hudson & Fivush, 1991; Murachver et al., 1996; Pipe & Wilson, 1994; Poole & White, 1993; Wagenaar, 1986), or emphasized the qualities of the recollections, such as vividness (e.g., Herz & Schooler, 2002; Rubin et al., 1984). Thus, possibly, the ESK quantification method employed in the present study provides a relatively sensitive measure to detect subtle differences in detailed recall.

Whether the ESK quantification method influenced the results of this study is difficult to confirm. Comparing this method with other methods is difficult because these other methods either do not have specific rules or they focused primarily on validity. Only one method (in a different type of study) can be more or less compared with the method used in this paper: However, while Brown and Kulik's (1977) method did organize written accounts into useful content categories for their topic of flashbulb memories, the method did not check for ESKs or ESK details. In general, one can say that, to the authors' knowledge, the method described in this paper is the most precise and detailed one for quantitatively counting ESKs in written free-recall accounts; perhaps that is why it yielded high interrater reliability scores.

The mechanism underlying the current finding, that the no-cue condition elicited more memory details than the cue conditions, also could originate from the cues used. They might not have been comparable, for example, in aspects such as properties, typicality, or uniqueness. For example, we know from word cues that certain properties, such as imagery, concreteness, and meaningfulness, have an effect on the age of the recalled autobiographical memories (Rubin & Schulkind, 1997). And for prospective memory, it was found that cue typicality (Mäntylä, 1993) and cue target uniqueness (Mäntylä & Nilsson, 1988) both have an effect on the numbers of successfully recalled memories, in the sense that typical and unique cues were more successful. All of these cue aspects could have played a role in the experiment described in this paper. However, as far as the authors are aware, these effects have not been studied comparing cues consisting of different combinations of modalities.

More problematic methodological difficulties arise when cuing memories from real-life events are the topic of investigation. In real-life events, the possibilities for systematically manipulating different cue aspects are limited because the cues should be a natural part of the context of the event to guarantee ecological validity. Moreover, it should be possible to retrieve cues from the actual recordings of the real-time event that took place in the past. For the study presented in this paper that aimed at comparing different combinations of modalities, there was not much choice as far as the cues were concerned, in that the activity objects were fixed, just as the smells were. During each activity, one particular smell was present in the room and each participant created one object. For the videos, a short clip was selected that contained footage showing an overview of the room, a still of such an overview was printed for the photo cue; the sounds in the video clip were the typical sounds of the activity, and these same sounds were used as the sound cue. Even though cue aspects, such as typicality and uniqueness, could well have played a role in the results of our experiment, we do not see how we could have manipulated these cue aspects in such a real-life event.

Another interpretation may be that presenting cues makes people restrict their focus to certain perceptual aspects of their autobiographical memory. For example, looking at a photograph might prompt people to focus on what can be seen in that particular picture only and to not think about the events before or after the photo was taken. Chu and Downes (2002) speculate that visual cues induce a selective search strategy. Alternatively, according to Conway and Pleydell-Pearce's (2000) model, perceptual cues trigger autobiographical recall through direct retrieval. More specifically, direct retrieval involves the activation of autobiographical knowledge at the bottom level of recall (that of ESK), spreading to the upper levels of general events and lifetime periods. Perhaps when memories are elicited in this fashion, people do not easily engage in a more deliberate search strategy that would produce more or other types of detail. In contrast, a free-recall question, such as employed in the no-cue condition, would prompt a more generative search strategy, in which the ESK is accessed from upper levels of the hierarchical autobiographical knowledge base. Perhaps such a top-down search strategy is more flexible, leaving room for more ESK details to emerge. Future studies could shed more light on this issue.

Another explanation for the result that the no-cue condition generated more memory details than the cue conditions could be that external cues in themselves already contain rich sources of information that people might find unnecessary to repeat in their memory description. This perspective can be difficult or even impossible to extract by outsiders. For example, when an audio recording of an event includes the sound of heavy rains, this weather condition might be obvious to the person who hears it as a cue, but he/she might not note this in a memory description because this information is already provided by the cue itself. On the other hand, an outsider who was not present during the recording might not recognize the sound as being rain. Therefore it is hard, if not impossible, for the experimenter in memory studies to judge how much embedded information in the cues remains unarticulated or unperceived by the participant.

A methodological issue that deserves consideration is the fact that each participant had to bring a friend, which makes them more likely to talk about their experiences and thus rehearse their memories together in between the Archeon visit and the test session. This may have obscured condition differences. Another issue is the rather small number of participants in the various cue conditions, which leaves room for influences of personal preference and



age. Nevertheless, it is not obvious how the finding that the cue condition had fewer ESKs than the no-cue condition can be attributed to a lack of power.

## **Analysis Method**

The main conclusion from evaluating the new method presented in this paper is that raters can objectively quantify the number of ESKs and ESK details in free-recall written accounts. This means that a workable definition of ESK has been found. In addition to the first two phases of the method, the identification of ESKs and ESK details, there was a third phase of subdividing the ESKs into different categories, namely: perception, reflection, state, action and object-specific knowledge. The value of this third phase could not really be evaluated, since the test-study's accounts focused on activities, leading to 61% ASKs. It has to be shown in different experimental settings whether these distinctions are useful for psychological research, especially the SSK, since Pipe and Wilson (1994) found that very few statements in free recall related to the context of the experience.

Comparing the results presented above with results from previous studies is difficult since only one study can be more or less compared with this method, namely Brown and Kulik (1977). The other studies either did not have specific rules that can be compared or they focused too much on validity, making their categories incomparable with the ones used in this paper. Brown and Kulik's method, on the other hand, did not check for ESKs or ESK details, but it did organize written accounts into useful content categories, such as place and informant. Their interrater agreements (also based on two raters trained for this one-time experiment) were high, namely 90%, but not as high as for this method. This lower value might be due to the fact that they did not work out in detail which unit would be used for the categorization, as we did for our ESKs. In general, one can say that the method described in this paper is the most precise and detailed one known to the authors for quantitatively counting ESKs in written free-recall accounts that also yielded high interrater reliability scores.

## **What Does This Mean for the Design of an Augmented Memory System?**

Contrary to expectations, the no-cue condition (text cue) was most effective in generating ESKs. Because ESKs are the smallest units of memory, they therefore have to be supported by an augmented memory system. The results of this experiment suggest that when designing systems or experiences for "remembering as much as possible," text should be the main cue type.

However, remembering-as-much-as-possible is only one aspect of the recollection process. Therefore, it might be unwise to rely only on text cues if the goal is to capture other aspects of remembering or to surface multiple aspects of recollection, since many dimensions of recollecting were not tested in this experiment. Examples of these additional dimensions are pleasure while recollecting, the ability to change the user's mood, the intensity of the memory, the effect of cues a long time after the memory-creation, the speed of the memory recall, and potential personal preferences for certain cue types. Although these dimensions were not investigated in this study, we believe that, for example, the pleasure of the recall process is larger with photos than with text only, especially in a situation where someone is communicating his/her memories to somebody else.

All in all, contrary to previous research, the present study shows that the no-cue condition (only text) for the recall of a real-life event generated significantly more ESKs compared to any of the cue conditions (artifact, picture, odor, sound and video). It may be that these cues have a filtering effect on the internal memory search, resulting in fewer autobiographical memories. But at the same time, we presume that these cues can be beneficial for the recollection process in certain conditions. Future studies may shed light on these possibilities.

### **What Does This Mean for Autotopography and External Cognition?**

The issue mentioned in the Discussion section that an external cue might already be a rich source of information that people do not identify or communicate easily, or would discount because it is self-evident, could be an interesting field for further study. Because “just as a photograph can take me back to a specific time and place, so can a pressed flower, a small seashell, or even a theater ticket stub” (Kollenbaum, 2002, p. 8); external cognition seems ubiquitous from a memory-recollecting perspective. Any physical artifact, environment, or even a person can serve as external cognition to a number of people. And this knowledge could be used while designing interactive systems. For example, incorporating existing artifacts that people already use and have a mental model of into the interaction with new systems, such as our souvenir interaction (Hoven & Eggen, 2005b) will open up new potential for design. For example, learnability could be lower and pleasure of use could be higher when incorporating artifacts that people already have decided to keep in their vicinity. In general, autotopography and Dcog should be studied in greater detail, for example, working on concept definitions and making inventories of the areas, since little research has been done so far. Future directions could also be based on combining the methods used in the DCog work with the topic of study described by the autotopography concept, particularly through experiments, more descriptive and observational approaches, or qualitative studies, such as ethnography. The strength of autotopography related to the topic of this paper is that it shows how important artifacts are for recall and that the use of these artifacts in the home is often implicit. Further development of the DCog concept would help, for example, to clarify the relation between autobiographical memory cuing and external cognition and make clear what distinguishes one from the other and how they complement each other.

## **CONCLUSIONS**

A method was developed in order to analyze the number of autobiographical recollections in written free-recall accounts, without checking the validity. This method focuses on ESKs (Conway & Pleydell-Pearce, 2000), which were identified based on a grammatical method, thereby avoiding interpretation of the accounts. In addition to identifying individual ESKs, the number of details contained in each ESK was counted, and a general ESK type was identified (describing perception, reflection, state, action or object).

Following the raters’ 10-hour of training on the method, the raters completed evaluation of each account within 5 to 10 minutes, on average, demonstrating the method’s rather straightforward and ease of use. In addition, the high interrater reliability (.97 for the number

of ESKs) shows that this method is an objective and reliable measure for a quantitative analysis of written accounts.

The purpose of the memory-cuing experiment was to examine what role various types of retrieval cues play in eliciting autobiographical memories. This knowledge is considered crucial for the design of a future hand-held device that supports users in reconstructing and sharing personal memories in their home environment. (For more information, see Hoven, 2004; Hoven & Eggen, 2008). An experiment was set up in which 69 adults participated in a novel, real-life event (i.e., a visit to a history-themed park). One month later, recall was tested in a laboratory living room setting using one of five cue types (photos, videos, sounds, odors, artifacts) and a no-cue baseline. Experimental results showed that the cue type groups did not differ with respect to the number of units of ESKs recalled. However, overall, cuing rendered a significantly lower number of ESKs than that provided by no cue (only text). This suggests, first, that providing cues as part of an augmented memory system may hamper the level of detail of autobiographical memories, and/or, second, that cues contain information that people may think is obvious and therefore might not want to repeat in their memory descriptions.

In general, we believe that text cues could result in reconstructed memories that provide the structure of a story. Simultaneously, other types of media could serve as a support for this story by filling in detailed aspects of these memories, that is, by means of physical artifact, photo, smell, sound, and video cues.

---

## ENDNOTES

1. The website for Archeon is <http://www.archeon.nl> and includes information in English.
2. The grammar terms presented here are English translations of Dutch concepts. Therefore, the terms may not equate directly to similar terminology or linguistic application in English or any other language. Nevertheless, the rationales behind the articulated process for counting ESKs could be transferrable to the unique grammar applications of other linguistic codes.

## REFERENCES

- Aggleton, J. P., & Waskett, L. (1999). The ability of odours to serve as state-dependent cues for real-world memories: Can Viking smells aid the recall of Viking experiences? *British Journal of Psychology*, *90*, 1–7.
- Balabanović, M., Chu, L. L., & Wolff, G. J. (2000). Storytelling with digital photographs. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '00)*; pp. 564–571. New York: ACM Press.
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, *5*, 73–99.
- Burt, C. D. B., Mitchell, D. A., Raggatt, P. T. F., Jones, C. A., & Cowan, T. M. (1995). A snapshot of autobiographical memory retrieval characteristics. *Applied Cognitive Psychology*, *9*, 61–74.
- Bush, V. (1945). As we may think. *The Atlantic Monthly* [online]. Retrieved May 8, 2009, from <http://www.theatlantic.com/doc/194507/bush>
- Chu, S., & Downes, J. J. (2002). Proust nose best: Odors are better cues of autobiographical memory. *Memory and Cognition*, *30*, 511–518.
- Clarkson, B., Mase, K., & Pentland, A. (2001). The familiar: A living diary and companion. In *Proceedings of the CHI'01 Extended Abstracts on Human Factors in Computing Systems (CHI '01)*; pp. 271–272. New York: ACM Press.

- Cohen, G. (1996). *Memory in the real world*. Hove, UK: Psychology Press.
- Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*, 261–288.
- Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., & Spasojevic, M. (2002). Rememberer: A tool for capturing museum visits. In G. Borriello & L. E. Holmquist (Eds.), *UbiComp 2002: Ubiquitous Computing, 4<sup>th</sup> International Conference* (pp. 48–55). Berlin, Germany: Springer.
- Frohlich, D. M., & Murphy, R. (2000). The memory box. *Personal Technologies*, *4*, 238–240.
- Gee, S., & Pipe, M.-E. (1995). Helping children to remember: The influence of object cues on children's accounts of a real event. *Developmental Psychology*, *31*, 746–758.
- Gemmell, J., Bell, G., Lueder, R., Drucker, S., & Wong, C. (2002). MyLifeBits: Fulfilling the memex vision. In *Proceedings of the Tenth ACM International Conference on Multimedia (Multimedia'02)*; pp. 235–238). New York: ACM.
- Glos, J. W., & Cassell, J. (1997). Rosebud: A place for interaction between memory, story, and self. In *Proceedings of the 2nd International Conference on Cognitive Technology (CT'97)*; p. 88). Washington, DC, USA: IEEE Computer Society.
- González, J. A. (1995). Autotopographies. In G. Brahm, Jr. & M. Driscoll (Eds.), *Prosthetic territories: Politics and hypertechnologies* (pp. 133–150). Boulder, CO, USA: Westview Press.
- Harman, J. (2001). Creating a memory palace using a computer. In *Proceedings of the CHI'01 Extended Abstracts on Human Factors in Computing Systems (CHI'01)*; pp. 407–408). New York: ACM Press.
- Herz, R. S., & Schooler, J. W. (2002). A naturalistic study of autobiographical memories evoked by olfactory and visual cues: Testing the Proustian hypothesis. *American Journal of Psychology*, *115*, 21–32.
- Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction research. *ACM Transactions on Computer-Human Interaction*, *7*, 174–196.
- Hoven, E. van den (2004). *Graspable cues for everyday recollecting* [doctoral dissertation]. Eindhoven, the Netherlands: Industrial Design Department, Eindhoven University of Technology.
- Hoven, E. van den, & Eggen, B. (2003). Digital photo browsing with souvenirs. In G. W. M. Rauterberg, M. Menozzi, & J. Wesson (Eds.), *Human-computer interaction INTERACT'03* (pp. 1000–1004). Amsterdam: IOS Press.
- Hoven, E. van den, & Eggen, B. (2005a, January). *A quantitative method for counting recollections in written free-recall accounts*. Paper presented at the 6th Biennial Meeting of the Society for Applied Research in Memory and Cognition (SARMAC VI), Wellington, New Zealand.
- Hoven, E. van den, & Eggen, B. (2005b). Personal souvenirs as ambient intelligent objects. In *Proceedings of the 2005 Joint Conference on Smart Objects and Ambient Intelligence (sOc-EUSAI 2005)*; pp. 123–128). New York: ACM Press.
- Hoven, E. van den, & Eggen, B. (2008). Informing augmented memory system design through autobiographical memory theory. *Personal and Ubiquitous Computing*, *12*, 433–443.
- Hoven, E. van den, Eggen, B., & Wessel, I. (2003, July). *Context-dependency in the real world: How different retrieval cues affect event-specific knowledge in recollections of a real-life event*. Paper presented at the 5th Biennial Meeting of the Society for Applied Research in Memory and Cognition (SARMAC V), Aberdeen, Scotland.
- Hudson, J. A., & Fivush, R. (1991). As time goes by: Sixth graders remember a kindergarten experience. *Applied Cognitive Psychology*, *5*, 347–360.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA, USA: MIT Press.
- Ikei, Y., Hirose, Y., Hirota, K., & Hirose, M. (2003). iFlashback: A wearable system for reinforcing memorization using interaction records. In J. Jacko & C. Stephanidis (Eds.), *Proceedings of the Tenth International Conference on Human-Computer Interaction 2003 (HCI-Int. 2003)*; pp. 754–758). Heraklion, Greece: Lawrence Erlbaum Associates.

- Kollenbaum, L. (2002). *Souvenirs de Voyage, A Traveler's Keepsake Book*. San Francisco: Chronicle Books.
- Lamming, M., & Flynn, M. (1994). "Forget-me-not" intimate computing in support of human memory. Retrieved May 8, 2009, from <http://www.lamming.com/mik/Papers/fmn.pdf>
- Mäntylä, T. (1993). Priming effects in prospective memory. *Memory*, 1, 203–218.
- Mäntylä, T., & Nilsson, L.-G. (1988). Cue distinctiveness and forgetting: Effectiveness of self-generated retrieval cues in delayed recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 502–509.
- Moscovitch, M. (1995). Models of consciousness and memory. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 1341–1356). London: MIT Press.
- Murachver, T., Pipe, M.-E., Gordon, R., Owens, J. L., & Fivush, R. (1996). Do, show, and tell: Children's event memories acquired through direct experience, observation, and stories. *Child Development*, 67, 3029–3044.
- Perry, M. (2003). Distributed cognition. In J. M. Carroll (Ed.), *HCI models, theories and frameworks: Toward a multidisciplinary science* (pp. 193–223). San Francisco: Elsevier Science.
- Piernot, P. P., Felciano, R. M., Stancel, R., Marsh, J., & Yvon, M. (1995). Designing the PenPal: Blending hardware and software in a user-interface for children. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '95)*; pp. 511–518). Denver, CO, USA: MIT Press.
- Pipe, M.-E., & Wilson, J. C. (1994). Cues and secrets: Influences on children's event reports. *Developmental Psychology*, 30, 515–525.
- Poole, D. A., & White, L. T. (1993). Two years later: Effects of question repetition and retention interval on the eyewitness testimony of children and adults. *Developmental Psychology*, 29, 844–853.
- Preece, J., Rogers, J., & Sharp, H. (2002). *Interaction design*. New York: Wiley.
- Rogers, Y. (1997). A brief introduction to distributed cognition. Retrieved May 8, 2009, from <http://www.slis.indiana.edu/faculty/yrogers/papers/dcog/dcog-brief-intro.pdf>
- Rubin, D. C., Groth, E., & Goldsmith, D. J. (1984). Olfactory cuing of autobiographical memory. *American Journal of Psychology*, 97, 493–507.
- Rubin, D. C., & Schulkind, M. D. (1997). Properties of word cues for autobiographical memory. *Psychological Reports*, 81, 47–50.
- Scaife, M., & Rogers, Y. (1996). External cognition: How do graphical representations work? *International Journal of Human-Computer Studies*, 45, 185–213.
- Schacter, D. L. (1996). *Searching for memory: The brain, the mind and the past*. New York: Basic Books.
- Schütte, A. A. (1998). *Patina: Layering a history-of-use on digital objects*. Unpublished master's thesis, Massachusetts Institute of Technology, Cambridge, MA, USA.
- Shen, C., Lesh, N., & Vernier, F. (2003). Personal digital historian: Story sharing around the table. *interactions*, 10(2), 15–22.
- Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin and Review*, 8, 203–220.
- Starnes, T., Mann, S., Rhodes, B., Levine, J., Healey, J., Kirsch, D., Picard, R., & Pentland, A. (1997). Augmented reality through wearable computing. *Presence*, 6, 386–398.
- Stevens, M. M., Abowd, G. D., Truong, K. N., & Vollmer, F. (2003). Getting into the living memory box: Family archives & holistic design. *Personal and Ubiquitous Computing*, 7, 210–216.
- Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.
- Vaidya, C. J., & Gabrieli, J. D. E. (2000). Picture superiority in conceptual memory: Dissociative effects of encoding and retrieval tasks. *Memory and Cognition*, 28, 1165–1172.
- Wagenaar, W. A. (1986). My memory: A study of autobiographical memory over six years. *Cognitive Psychology*, 18, 225–252.

---

## Author's Note

The authors thank L. Reynders and J. van den Heuvel for implementing and improving the method described in this paper by rating the questionnaires, J. and A. Hoonhout for helping with (Dutch) grammar, M. Rauterberg and A. Kohlrausch for testing the first versions of the analysis method, and I. Wessel for her endless support in guiding us through the autobiographical memory field.

The experiment described in this paper was presented at the Human–Computer Interaction International conference (HCI-Int. 2003), held in Crete, Greece, June 2003.

All correspondence should be addressed to:

Elise van den Hoven  
Industrial Design Department  
Eindhoven University of Technology  
P. O. Box, 513  
5600 MB Eindhoven  
The Netherlands  
e.v.d.hoven@tue.nl

---

*Human Technology: An Interdisciplinary Journal on Humans in ICT Environments*  
ISSN 1795-6889  
[www.humantechnology.jyu.fi](http://www.humantechnology.jyu.fi)