

ReMindMe: Agent-Based Support for Self-Disclosure of Personal Memories in People with Alzheimer’s Disease

Marieke M.M. Peeters

Delft University of Technology, Interactive Intelligence group, Delft, The Netherlands
m.m.m.peeters@tudelft.nl

Keywords: Human-Agent Relationships, Conversational Agent, Ontology, Self-Disclosure, Dementia

Abstract: This paper presents work on the design rationale and architecture of ReMindMe. ReMindMe aims to provide agent-based support for people with Alzheimer’s disease and their social environment by playing music with a strong personal meaning to the patient so as to activate personal memory recall. ReMindMe stimulates reminiscence and self-disclosure of personal memories. Through long-term interaction with the patient, the ReMindMe agent gradually constructs a knowledge base containing information about the patient’s life stories. The agent uses this knowledge base to engage in mutual conversational self-disclosure about personal memories so as to stimulate reminiscence. Future research aims to develop and refine ReMindMe through coactive design and testing ‘in the wild’, i.e. at dementia care facilities. The envisioned outcome of the project is a usable and effective proof-of-concept of a conversational agent for the dementia care practice.

ENVISIONED SCENARIO

Over the past two years, Mrs. de Vries’s dementia progressively worsened. It became difficult for her to keep a conversation or play a game. Her granddaughter, Susan, no longer knew how to connect with her grandmother and visited less and less frequent. As of late, however, Susan has found a new way to interact with her grandmother: through ReMindMe.

Susan enters her grandmother’s room in the nursing home and sits down next to her grandmother. She asks if Mrs. de Vries would like to listen to music together. When Mrs. de Vries nods, Susan asks ReMindMe to play music from the playlist “Adolescence (1940–1945)”. The song “Lili Marleen” by Marlene Dietrich starts playing.

ReMindMe knows about facts and anecdotes from Mrs. de Vries’s life between 1940 and 1945. It uses this knowledge to engage in conversation with Susan and Mrs. de Vries: “It was 1945. You were staying at your aunt’s house, when the allied forces arrived. The tanks drove down the streets, and American soldiers were handing out chocolate and cigarettes.” Mrs. de Vries hums to the tune of the song and mumbles: “Yes, the tanks, the parade, and the flags.” Mrs. de Vries looks up at Susan. They smile at each other, while softly singing along with Marlene.

1 PROBLEM STATEMENT

The populations of modern societies are aging, causing the number of people with Alzheimer’s disease to rise each year (World Health Organization, 2015). Alzheimer’s disease has deteriorating effects on patients’ emotional, cognitive, behavioural, and social functioning (van Gennip et al., 2014; Verhey, 2015). Patients’ memories are affected, causing them to forget where they put their keys, where they are, or where they live; they may no longer recognize the important people in their life, know how to cook a meal, or how to follow a recipe. Such experiences can lead to feelings of lowered self-esteem, loss of autonomy, confusion, depression, and anxiety (Alzheimer’s Association, 2015).

As of yet, there exists no treatment to cure Alzheimer’s disease (World Health Organization, 2015). Medicinal treatments of Alzheimer’s disease primarily aim to reduce the syndrome’s negative effects, yet the benefits of available medicinal treatments often do not outweigh their negative side-effects (Banerjee et al., 2009; Koopmans et al., 2015).

An alternative to medicinal treatments, is the use of *psychosocial interventions*: non-medicinal treatments that aim to support and improve the quality of life for people with Alzheimer’s disease, while moderating the negative implications caused by the syndrome (Droës et al., 2006; Lawrence et al., 2012;

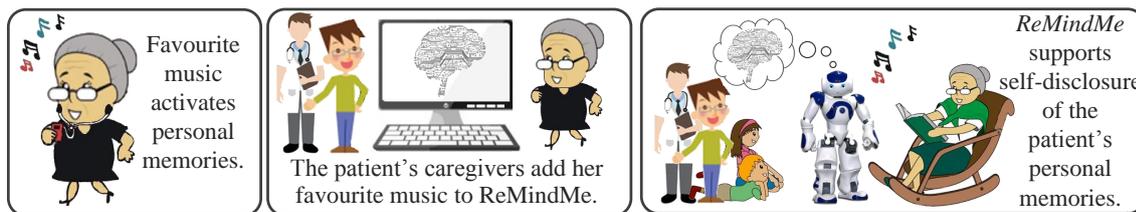


Figure 1: ReMindMe: agent-based support for the dementia care practice.

Riley et al., 2009). Patients greatly benefit from a supportive social environment that regards them as complete individuals rather than as people with Alzheimer’s disease (van Gennip et al., 2014). And so, psychosocial interventions also take patients’ social environment into account, e.g. family, friends, and caregivers (Droës et al., 2006; Lawrence et al., 2012; van Gennip et al., 2014; Wallace et al., 2012). This holistic view on dementia care is particularly important as the disabilities caused by Alzheimer’s disease often force patients to increasingly rely on their social environment, causing a major physical, emotional, and economic impact on the lives of their family and friends (Alzheimer’s Association, 2015; van Gennip et al., 2014; Verhey, 2015).

2 DESIGN RATIONALE

This paper introduces preliminary work on the design and architecture of a system called ReMindMe: an agent-based support system for people with Alzheimer’s disease and their social environment (also see Figure 1). It also describes a research proposal for the further development and evaluation of this system.

ReMindMe helps patients and their caregivers in two ways. First of all, it aids patients in recalling personal memories, thereby reinforcing their sense of identity, security, safety, and self-esteem (Droës et al., 2006; Lawrence et al., 2012; van Gennip et al., 2014; Wallace et al., 2012). Second, ReMindMe stimulates self-disclosure, i.e. the mutual sharing of personal memories with kindred parties (Derlega et al., 2008; Dindia et al., 2002; Greene et al., 2006). Self-disclosure is important for the development and maintenance of high-quality interpersonal relationships. Such relationships are characterised by a mutual liking, familiarity, and security (Chan and Cheng, 2004; Collins and Miller, 1994; Greene et al., 2006; Pecune et al., 2013; Pecune et al., 2014). Thus, self-disclosure of personal memories between patients and caregivers helps staff personnel and informal caregivers to improve their delivery of care, due to an improved awareness of patients’ personal needs, and it

helps patients in developing a sense of companionship and acceptance (Cooney et al., 2014; Haight et al., 2006; Subramaniam and Woods, 2012; Subramaniam et al., 2014; Thieme et al., 2011; van Gennip et al., 2014).

Research suggests that the musical memory remains largely unaffected in Alzheimer’s Disease. This allows for the musical memory to act as a gateway to memories of lifetime events, even if such access can no longer be achieved through a verbal route (Clark and Warren, 2015; Cuddy and Duffin, 2005; Cuddy et al., 2015; Jacobsen et al., 2015; Janata et al., 2007; McDermott et al., 2014; Norman-Haignere et al., 2015; Sarkamo et al., 2014; Schulkind and Woldorf, 2005; Simmons-Stern et al., 2012; Sixsmith and Gibson, 2007; Ueda et al., 2013; Vasilyte and Madison, 2013). Therefore, to activate the patient’s brain and autobiographical memory, ReMindMe uses personalized music, which is to be provided by the patient’s family and friends.

3 THE REMINDME AGENT

Spoken language is the most natural way of communication, especially for people with Alzheimer’s disease. And so the ReMindMe agent will be capable of engaging in vocal communication. The agent will use either a NAO robot or a virtual agent for its body.

The ReMindMe agent engages in conversational self-disclosure to develop its relationship with the patient. This means that the agent must itself be a worthy interlocutor for people with Alzheimer’s disease, capable of developing and maintaining an equal, confidential, and secure relationship with the patient (Breazeal, 2004; Fiske, 1992).

Self-disclosure is expressed in the following ways: (a) refer to mutual knowledge more often (Planalp and Benson, 1992; Richards and Bransky, 2014); (b) share an increasing amount, breadth, and depth of personal information (Bickmore et al., 2009; Bickmore and Schulman, 2012; Collins and Miller, 1994); and (c) paraphrase the user’s utterances more often (Cassell et al., 2007).

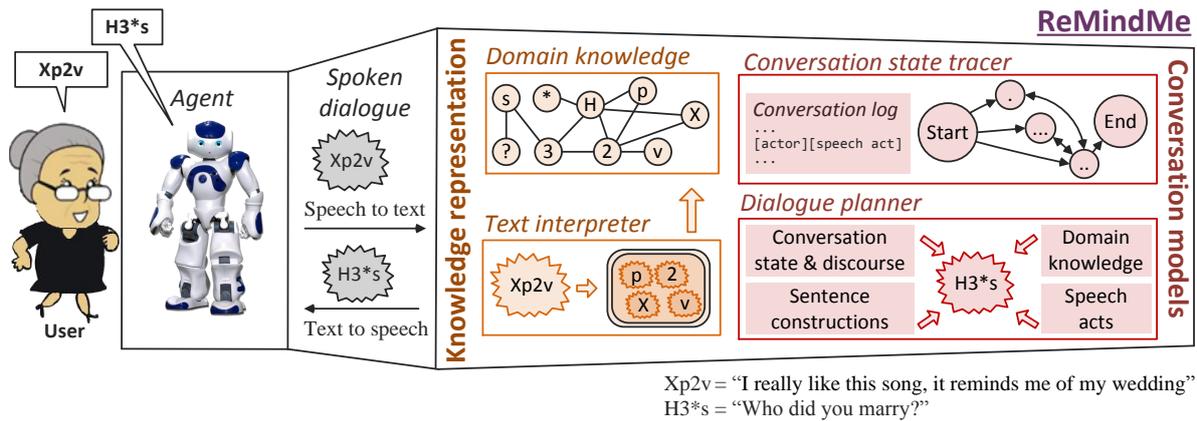


Figure 2: The ReMindMe architecture

The extent to which the agent self-discloses should gradually increase as the relationship advances. The ReMindMe agent will use a computational model to determine the appropriate level of self-disclosure. The level of self-disclosure is determined using a classification scheme by (Barak and Gluck-Ofri, 2007). The agent reciprocates the user's level of self-disclosure by discussing only things deemed appropriate for the topic and level of self-disclosure chosen by the user.

Because of the reciprocal nature of self-disclosure, the agent needs an identity and 'personal memories' to be accepted as a worthy interlocutor. The framework provides the agent with an identity and memories by using fictitious 'back stories' (e.g. name, personal memories, favourite music). Although one might find this deceitful, research suggests people perceive this as engaging and enjoyable (Bickmore et al., 2009).

4 PROPOSED RESEARCH

The ReMindMe architecture (also see Figure 2) describes a computational model that senses the current relationship status and provides corresponding self-disclosure speech acts (i.e., questions or 'own' experiences). The content, depth, and style of dialogue are derived from the domain knowledge representation and prior conversations (i.e., 'shared experiences') while maintaining conversational flow. The architecture consists of the following components:

Text interpreter. ReMindMe will use off-the-shelf speech-to-text (Nuance's Dragon) and text-to-speech (Acapela) technology. A domain knowledge representation will enable the agent to grasp the underlying meaning of the user's utterances. Example: The agent grasps that this song is related to a happy memory of

the user's wedding as it recognizes utterances 'I like', 'song', and 'wedding'.

Domain knowledge. The domain knowledge representation - to be developed with the use of ontology engineering (Noy and McGuinness, 2001; Peeters et al., 2014b) - will contain general prior knowledge about levels of self-disclosure, relationships, personal memories, and music; and specific prior knowledge about the agent's back story. It will conversation, and relationship. Example: the agent knows 'wedding' means 'two people getting married'.

Conversation state tracer. The state tracer will keep track of the conversational discourse and state. Example: The agent knows that 'this song' refers to Elvis' 'Love me tender'.

Dialogue planner. The dialogue planner will enable the agent to construct sentences that, i.a., (1) self-disclose information, (2) ask questions, (3) paraphrase the user, and (4) resolve miscommunication. Example: The agent asks "Who did you marry?"

5 APPROACH

The ReMindMe system will be developed and evaluated by conducting a series of user-based studies (see Table 1) following situated Cognitive Engineering (Neerincx and Lindenberg, 2008; Neerincx, 2011; Peeters et al., 2012): a human-computer interaction design methodology with a strong focus on theory development through the systematic generation and testing of hypotheses. To carefully handle privacy considerations, the project will employ best practices of Value-Sensitive Design (Friedman et al., 2013).

Participants. The target groups are (a) people with mild to moderate dementia - as determined by dementia care professionals -, and (b) their informal and (c) professional caregivers. Participating patients still

Table 1: The research approach of ReMindMe

Activity	Description
Human-human study	Patients and informal caregivers engage in <i>conversation sessions</i> * in mixed pairs.
Design conversation models	Outcomes of the human-human study are used to model (1) conversation states and transitions between them; (2) a set of appropriate speech acts for each conversational state; (3) sentence constructions for speech acts; and (4) a conversation log to determine the conversational discourse.
Needs assessment	All target groups participate in structured group interviews (Beer et al., 2012; Peeters, 2014) at their meeting centres to obtain information about the needs of the target groups in relation to personal memory support, and opportunities and requirements for a ReMindMe application to meet those needs.
Scripted human-human study	Patients engage in single <i>conversation sessions</i> * with the experimenter, who strictly follows the designed conversation models.
Adjust conversation models	Adjust conversation models based on outcomes of scripted human-human study.
Design knowledge representation	Design a domain knowledge representation based on outcomes of both non-scripted and scripted human-human study, using ontology engineering (Noy and McGuinness, 2001; Peeters et al., 2014b).
Wizard-of-oz study	Patients participate in single <i>conversation sessions</i> * with the agent in a <i>Wizard-of-Oz set-up</i> : unbeknown to the user, the experimenter simulates the agent's behaviour (Bernsen et al., 1994; Peeters et al., 2014a).
Expert review	Dementia care professionals and clinical psychologists review the ontology following an ontology review method, described in (Peeters et al., 2014b).
Adjust framework	Adjust framework based on outcomes of Wizard-of-Oz study.
Implement prototype	Implement prototype with the aid of a programmer.
Pilot study	Patients participate in a run-through of the proof-of-concept evaluation to check the experimental set-up and prototype usability.).
Adjust prototype	Adjust prototype based on outcomes of pilot study.
Proof-of-concept study	Patients engage in 12 <i>conversation sessions</i> * 2 or 3 days apart with the - fully implemented and autonomously functioning - agent.

live in their own homes and visit meeting centres on weekdays for daytime activities with other patients. Patients with severe dementia may have difficulty engaging with the agent, and so are excluded from participation. People with dementia are a vulnerable target group, meaning careful attention is paid to ethical conduct, e.g. informed consent and data storage.

* *Conversation sessions - procedure.* Patients and their conversational partners (i.e. informal caregiver, experimenter, or agent) take turns playing their favourite music and asking each other about associated memories for 30 minutes at their regular meeting centres. Participants are encouraged to follow up on each other's stories. During all sessions, a trusted caregiver will be present to step in if needed.

6 CONCLUSION

This paper proposes the design and development of an agent-based support system for people with Alzheimer's disease and their social environment, called ReMindMe. The envisioned system will stim-

ulate patients to reminisce about personal memories and engage in self-disclosure about those memories. The agent itself will also be able to engage in conversations about personal memories with the patient, thereby relieving from time to time the patients' caregivers. As the agent develops an equal, confidential, and secure relationship with the patient, the agent can serve as a trusted companion when the patient transitions from the trusted home environment to a new care facility. We expect that ReMindMe will greatly contribute to the dementia care practice as a complementary tool that implements three effective psychosocial interventions: trigger memory recall with the use of music, reminiscence, and self-disclosure.

ACKNOWLEDGEMENTS

The author would like to thank prof. Mark A. Neerincx, prof. Catholijn M. Jonker, dr. Koen V. Hindriks, dr. Karel van den Bosch, and prof. Dirk K.J. Heylen for their feedback on the ideas expressed in this paper.

REFERENCES

- Alzheimer's Association (2015). Dementia - Signs, Symptoms, Causes, Tests, Treatment, Care.
- Banerjee, S., Samsi, K., Petrie, C. D., Alvir, J., Treglia, M., Schwam, E. M., and del Valle, M. (2009). What do we know about quality of life in dementia? A review of the emerging evidence on the predictive and explanatory value of disease specific measures of health related quality of life in people with dementia. *International Journal of Geriatric Psychiatry*, 24(1):15–24.
- Barak, A. and Gluck-Ofri, O. (2007). Degree and Reciprocity of Self-Disclosure in Online Forums. *CyberPsychology & Behavior*, 10(3):407–417.
- Beer, J. M., Smarr, C.-A., Chen, T. L., Prakash, A., Mitzner, T. L., Kemp, C. C., and Rogers, W. A. (2012). The domesticated robot: design guidelines for assisting older adults to age in place. In *Proceedings of the annual ACM/IEEE international conference on Human-Robot Interaction*, pages 335–342. ACM.
- Bernsen, N. O., Dybkjær, H., and Dybkjær, L. (1994). Wizard of oz prototyping: How and when. *Proc. CCI Working Papers Cognit. Sci./HCI, Roskilde, Denmark*.
- Bickmore, T. and Schulman, D. (2012). Empirical validation of an accommodation theory-based model of user-agent relationship. In *Intelligent Virtual Agents*, pages 390–403. Springer.
- Bickmore, T., Schulman, D., and Yin, L. (2009). Engagement vs. deceit: Virtual humans with human autobiographies. In *Proceedings of the International Conference on Intelligent Virtual Agents*, pages 6–19. Springer.
- Breazeal, C. (2004). Social Interactions in HRI: The Robot View. *IEEE Transactions on Systems, Man and Cybernetics*, 34(2):181–186.
- Cassell, J., Gill, A. J., and Tepper, P. A. (2007). Coordination in conversation and rapport. In *Proceedings of the workshop on Embodied Language Processing*, pages 41–50. Association for Computational Linguistics.
- Chan, D. K.-S. and Cheng, G. H.-L. (2004). A Comparison of Offline and Online Friendship Qualities at Different Stages of Relationship Development. *Journal of Social and Personal Relationships*, 21(3):305–320.
- Clark, C. C. and Warren, J. D. (2015). Music, memory and mechanisms in Alzheimers disease. *Brain*, 138(8):2122–2125.
- Collins, N. L. and Miller, L. C. (1994). Self-disclosure and liking: a meta-analytic review. *Psychological bulletin*, 116(3):457.
- Cooney, A., Hunter, A., Murphy, K., Casey, D., Devane, D., Smyth, S., Dempsey, L., Murphy, E., Jordan, F., and O'Shea, E. (2014). 'Seeing me through my memories': a grounded theory study on using reminiscence with people with dementia living in long-term care. *Journal of Clinical Nursing*, 23(23-24):3564–3574.
- Cuddy, L. L. and Duffin, J. (2005). Music, memory, and Alzheimer's disease: is music recognition spared in dementia, and how can it be assessed? *Medical Hypotheses*, 64(2):229–235.
- Cuddy, L. L., Sikka, R., and Vanstone, A. (2015). Preservation of musical memory and engagement in healthy aging and Alzheimer's disease: Musical memory in Alzheimer's disease. *Annals of the New York Academy of Sciences*, 1337(1):223–231.
- Derlega, V. J., Winstead, B. A., and Greene, K. (2008). Derlega et al. Self-disclosure and starting a close relationship. In Sprecher, S., Wenzel, A., and Harvey, J., editors, *Handbook of relationship initiation*, pages 153–174. Psychology Press, New York, NY, US.
- Dindia, K., Allen, M., Preiss, R., Gayle, B., and Burrell, N. (2002). Self-disclosure research: Knowledge through meta-analysis. *Interpersonal communication research: Advances through meta-analysis*, pages 169–185.
- Droës, R.-M., Boelens-van der Knoop, E. C. C., Bos, J., Meihuizen, L., Ettema, T. P., Gerritsen, D., Hoogeveen, F., De Lange, J., and Scholzel-Dorenbos, C. (2006). Quality of life in dementia in perspective - An explorative study of variations in opinions among people with dementia and their professional caregivers, and in literature. *Dementia*, 5(4):533–558.
- Fiske, A. P. (1992). The Four Elementary Forms of Sociality: Framework for a Unified Theory of Social Relations. *Psychological Review*, 99(4):689–723.
- Friedman, B., Kahn, Jr., P., Borning, A., and Hultgren, A. (2013). Value sensitive design and information systems. *Early engagement and new technologies: Opening up the laboratory*, pages 55–95.
- Greene, K., Derlega, V. J., and Mathews, A. (2006). Self Disclosure in Personal Relationships. In *The Cambridge Handbook of Personal Relationships*, pages 409–427. Cambridge University Press, New York, NY, US.
- Haight, B. K., Gibson, F., and Michel, Y. (2006). The Northern Ireland life review/life storybook project for people with dementia. *Alzheimer's & Dementia*, 2(1):56–58.
- Jacobsen, J.-H., Stelzer, J., Fritz, T. H., Chtelat, G., La Joie, R., and Turner, R. (2015). Why musical memory can be preserved in advanced Alzheimers disease. *Brain*, 138(8):2438–2450.
- Janata, P., Tomic, S. T., and Rakowski, S. K. (2007). Characterisation of music-evoked autobiographical memories. *Memory*, 15(8):845–860.
- Koopmans, R., Olde Rikkert, M., and Zuidema, S. (2015). Medicamenteuze behandeling van dementie. In *Meer kwaliteit van leven - Integratieve persoonsgerichte dementiezorg*, pages 47–63. Diagnosis Uitgevers, Leusden, the Netherlands.
- Lawrence, V., Fossey, J., Ballard, C., Moniz-Cook, E., and Murray, J. (2012). Improving quality of life for people with dementia in care homes: making psychosocial interventions work. *The British Journal of Psychiatry*, 201(5):344–351.
- McDermott, O., Orrell, M., and Ridder, H. M. (2014). The importance of music for people with dementia: the perspectives of people with dementia, family carers, staff and music therapists. *Aging & Mental Health*, 18(6):706–716.

- Neerincx, M. A. (2011). Situated cognitive engineering for crew support in space. *Personal and Ubiquitous Computing*, 15(5):445–456.
- Neerincx, M. A. and Lindenberg, J. (2008). Situated cognitive engineering for complex task environments. In *Naturalistic Decision Making and Macrocognition*, pages 373–390. Ashgate.
- Norman-Haignere, S., Kanwisher, N., and McDermott, J. (2015). Distinct Cortical Pathways for Music and Speech Revealed by Hypothesis-Free Voxel Decomposition. *Neuron*, 88(6):1281–1296.
- Noy, N. and McGuinness, D. (2001). Ontology Development 101: A guide to creating your first ontology. Technical report, Knowledge Systems Laboratory, Stanford University.
- Pecune, F., Ochs, M., and Pelachaud, C. (2013). A Formal Model of Social Relations for Artificial Companions. In *Proceedings of The European Workshop on Multi-Agent Systems (EUMAS)*.
- Pecune, F., Ochs, M., and Pelachaud, C. (2014). A Cognitive Model of Social Relations for Artificial Companions. In *Intelligent Virtual Agents*, pages 325–328. Springer.
- Peeters, M. M. M. (2014). *Personalized Educational Games - An agent-based architecture for automated scenario-based training*. PhD thesis, Utrecht University.
- Peeters, M. M. M., van den Bosch, K., Meyer, J.-J. C., and Neerincx, M. A. (2012). Situated Cognitive Engineering: the Requirements and Design of Directed Scenario-based Training. In Miller, L. and Roncagliolo, S., editors, *Proceedings of the International Conference on Advances in Computer-Human Interaction*, pages 266–272. Xpert Publishing Services.
- Peeters, M. M. M., van den Bosch, K., Meyer, J.-J. C., and Neerincx, M. A. (2014a). The Design and Effect of Automated Directions During Scenario-based Training. *Computers & Education*, 70:173–183.
- Peeters, M. M. M., van den Bosch, K., Neerincx, M. A., and Meyer, J.-J. C. (2014b). An Ontology for Automated Scenario-based Training. *International Journal of Technology Enhanced Learning*, 6(3):195–211.
- Planalp, S. and Benson, A. (1992). Friends' and acquaintances' conversations I: Perceived differences. *Journal of Social and Personal Relationships*, 9(4):483–506.
- Richards, D. and Bransky, K. (2014). ForgetMeNot: What and how users expect intelligent virtual agents to recall and forget personal conversational content. *International Journal of Human-Computer Studies*, 72(5):460–476.
- Riley, P., Alm, N., and Newell, A. (2009). An interactive tool to promote musical creativity in people with dementia. *Computers in Human Behavior*, 25(3):599–608.
- Sarkamo, T., Tervaniemi, M., Laitinen, S., Numminen, A., Kurki, M., Johnson, J. K., and Rantanen, P. (2014). Cognitive, Emotional, and Social Benefits of Regular Musical Activities in Early Dementia: Randomized Controlled Study. *The Gerontologist*, 54(4):634–650.
- Schulkind, M. D. and Woldorf, G. M. (2005). Emotional organization of autobiographical memory. *Memory & cognition*, 33(6):1025–1035.
- Simmons-Stern, N. R., Deason, R. G., Brandler, B. J., Frustace, B. S., O'Connor, M. K., Ally, B. A., and Budson, A. E. (2012). Music-based memory enhancement in Alzheimer's Disease: Promise and limitations. *Neuropsychologia*, 50(14):3295–3303.
- Sixsmith, A. and Gibson, G. (2007). Music and the well-being of people with dementia. *Ageing and Society*, 27(01):127.
- Subramaniam, P. and Woods, B. (2012). The impact of individual reminiscence therapy for people with dementia: systematic review. *Expert Review of Neurotherapeutics*, 12(5):545–555.
- Subramaniam, P., Woods, B., and Whitaker, C. (2014). Life review and life story books for people with mild to moderate dementia: a randomised controlled trial. *Ageing & Mental Health*, 18(3):363–375.
- Thieme, A., Wallace, J., Thomas, J., Le Chen, K., Krämer, N., and Olivier, P. (2011). Lovers' box: Designing for reflection within romantic relationships. *International Journal of Human-Computer Studies*, 69(5):283–297.
- Ueda, T., Suzukamo, Y., Sato, M., and Izumi, S.-I. (2013). Effects of music therapy on behavioral and psychological symptoms of dementia: A systematic review and meta-analysis. *Ageing Research Reviews*, 12(2):628–641.
- van Gennip, I. E., W. Pasman, H. R., Oosterveld-Vlug, M. G., Willems, D. L., and Onwuteaka-Philipsen, B. D. (2014). How Dementia Affects Personal Dignity: A Qualitative Study on the Perspective of Individuals With Mild to Moderate Dementia. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, pages 1–11.
- Vasionyte, I. and Madison, G. (2013). Musical intervention for patients with dementia: a meta-analysis. *Journal of Clinical Nursing*, 22(9-10):1203–1216.
- Verhey, F. (2015). Klachten en verschijnselen van demetie. In *Meer kwaliteit van leven - Integratieve persoonsgerichte dementiezorg*, pages 163–184. Diagnosis Uitgevers, Leusden, the Netherlands.
- Wallace, J., Thieme, A., Wood, G., Schofield, G., and Olivier, P. (2012). Enabling self, intimacy and a sense of home in dementia: an enquiry into design in a hospital setting. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2629–2638. ACM.
- World Health Organization (2015). WHO - Dementia.