The potential for haptic touch technology to supplement human empathetic touch during radiotherapy

Simon Goldsworthy MSc[1,2], Caroline Zheng MSc [3] , Helen McNair PhD[4], Alison McGregor PhD[5]

1. Radiotherapy, Beacon Centre, Musgrove Park Hospital, Somerset NHS Foundation Trust, Taunton, United Kingdom.

2. Faculty of Health and Applied Sciences, University of the West of England, Bristol, United Kingdom.

3. Information Experience Design & Fashion, Royal College of Arts, London, United Kingdom

4. Radiotherapy Department, The Royal Marsden NHS Foundation Trust, London, United Kingdom

5. Faculty of Medicine, Department of Surgery & Cancer, Imperial College London, London, United Kingdom

Correspondence: simon.goldsworthy@SomersetFT.nhs.uk

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INTRODUCTION

Radiotherapy for cancer is an effective treatment requiring precise delivery. Outcomes are dependent on repeatable body positioning over many treatment sessions[1-2]. The current clinical solutions require patients to remain absolutely still in the same position over a period of 10-20 minutes, which can be uncomfortable[3-4]. This combined with the reported high anxiety experienced by patients[5-6], have indicated a need for comfort interventions to support patients receiving radiotherapy. Interventions which may have potential in increasing comfort in the radiotherapy setting include audio-visual, psychological, physical, education/information and aromatherapy[7]. There is suggestion that multiple interventions used concurrently could enhance effectiveness[7]. Empathetic touch converge both physical and psychological categories and could have potential to improve patient comfort (*Fig. 1*).

Figure 1. Comforting effect of Human Empathic Touch, courtesy of the COMFORT study

Care conveyed through empathetic touch promotes comfort, individual attention and presence. The unique character of empathetic touch is that it provides both psychological and physical comfort at the same time[8]. Evidence in nursing and care literature showed that

empathetic touch interventions have a significant role in promoting comfort, facilitating communication between care recipients and caregivers[9]. Empathetic touch is an intervention that has the potential to offer comfort during radiotherapy treatment[7] but the nature of the intervention can preclude this due to the requirements for safe and effective radiotherapy delivery.

During radiotherapy, once patients have been accurately positioned, they receive radiotherapy alone which can lead to feelings of isolation or loneliness[5]. Such sessions can take up to 20 minutes and patients are separated from the clinical team, their carers' and family during the treatment, and as such any reassurance from them in the form of touch during treatment is impossible. Not surprisingly up to 49% of patients experience stress and anxiety during the radiotherapy treatment[5-6], clearly we need to consider novel approaches to reducing stress and anxiety in this cohort to support them through treatments such as radiotherapy.

To contemplate novel approaches, we take inspiration from both human empathetic clinical practice in radiotherapy and affective haptic tactile touch technologies to envision the opportunities for haptic touch technology to supplement human empathetic touch during radiotherapy.

EMPATHETIC TOUCH IN RADIOTHERAPY

A large number of cancer patients are accessing complementary therapies for comfort and relaxation during radiotherapy[10]. In some services patients can access aromatherapy massage or reflexology to support them. There are often restrictions to the application of empathetic touch interventions due to the radiotherapy environment ensuring the safety of patients, professionals and the carers. This applies to both people and devices or objects that may attenuate the incidental radiotherapy beam which could lead to e.g. missing the planning target volume or collateral toxicity. Face to face empathetic touch interventions

usually cannot be administered during a radiotherapy session. According to Bolderston[11], radiation therapists value a humanistic and compassionate interaction with patients yet they have to work within the confines of the environment which prevents e.g. human touch. CCTV, intercom and audio systems are used when required to reassure patients, but this may not ameliorate feelings of isolation or reduce levels of patient anxiety. There are novel approaches such as the use of string for children to maintain empathetic contact with their parents during a radiotherapy session[12]. A child and parent can pull the string to let each other know they are at the end of the string as a form of empathetic touch to comfort the child.

Although there is limited evidence of empathetic touch interventions in radiotherapy, there are interventions from other healthcare settings which maybe applicable[13-14]. Some empathetic touch interventions come naturally to a caring health professional, for instance stroking someone's arm. There are potentially novel approaches to delivering empathetic touch using technology during a radiotherapy session that could make a positive change to patient experience which, with careful design, will not disrupt or impact the treatment delivered. Furthermore such interventions need to consider patient choice and preference (e.g. some patients may like music while others may prefer empathetic touch) requires the involvement of patients in the design and tailoring of the interventions[11] and to individually tailor interventions to the individuals[7].

UNDERSTANDING THE ATTRIBUTES OF EMPATHTIC TOUCH

The foundations of touch extend beyond the physiological sensations transmitted by neural pathways to the brain, moreover the sensations are felt both psychologically and sociologically[15]. Social and psychological touch ranges from unpleasant to pleasant, including; striking the skin, being pinched to shaking hands, kissing, and pleasant strokes in erogenous zones[15]. Touch in many ways is subjective and open to interpretation by the

individual: social touch interactions can, depending on the type and strength of the dyadic social relationship, elicit a plethora of physiological, emotional, and behavioural responses; both beneficial and disadvantageous (inappropriate touch)[16-18].

Historically, scientific research has viewed touch as serving only a discriminative role, which helps to differentiate the location of a stimulus on the skin, identify, haptically explore, and manipulate objects [19]. This discriminative touch system is mediated by a group of nerve fibres called Aβ afferents, which is characterised as being fast-conducting and myelinated. However, this does not explain why some forms of touch can feel pleasant. Recent studies have identified that the human body has a specialised neurophysiological system that mediate the affective properties of touch[20-21], which helps to explain the mechanisms underpinning the beneficial qualities of empathetic touch. Affective touch refers to tactile processing with a hedonic or emotional component[22]. Affective touch system is mediated by a different group of nerve fibres called CT-afferents, which are characterised as being slow conducting and unmyelinated. Such affective touch system projects via brain regions that are correlated with reward, emotion-related processing and social connection[20-21], which is a different neuropathway than discriminative touch system.

CT-afferents selectively respond to slow, gentle touch which is perceived as pleasant and socially supportive. On the contrary, faster, discriminative touch which allows a person to sense and localise touch shows no relationship with perceived pleasantness [20, 21, 23]. Gentle touch at a velocity of 1-10cm/s[23] is often called CT- optimal touch, as it most optimally excites the CT-afferents. CT-optimal touch has shown positive potential in alleviating stress[24], reducing feelings of social exclusion[25] and enhancing emotional bonding between children and caregivers[26].

CURRENT TREND IN AFFECTIVE HAPTIC TECHNOLOGIES

Derived from the Greek verb haptesthai, the word haptics means to touch. Haptic technologies create mechanical stimulation of force, vibration or motion to a patient, through a haptic device, which is usually a mechanical apparatus, to generate touch sensations for the purpose of feedback on environmental information, remote communication, and control[27]. The field of haptics is the most recent technology in computer interface devices and this new human computer interaction paradigm has brought together a variety of disciplines including biomechanics, psychology, neurophysiology, engineering and computer science [27-28]. Within this field, what is most relevant to our topic on envisioning empathetic touch in the radiotherapy environment is an emerging new research interest called affective haptics, which integrates ideas from affective computing, haptic technology and user experience and focuses on the design of devices and systems that can detect, process, or display the emotional state of the human by means of the sense of touch[28]. This led us to envision that empathetic touch be digitally transmitted via a haptic device promoting comfort and providing an alternative communication channel between care givers and patients.

There are existing works in the affective haptics field that create affective tactile stimulation devices for the application of psychological health and emotion communication via remote touch. Affective haptic technologies can apply to both wearable devices and robots that exchange physical contact with humans. We focus our discussion on wearable devices as we see it more relevant to the radiotherapy setting.

Working with mental health professionals, Vaucelle et al[29] were among the first researchers who provided proof-of-concept that a haptic stimulation prototype provided relief to patients with mental illness. Inspired by Sensory Grounding therapies in comforting the body and alleviating pain through tactile stimulation, the authors created a soft wearable piece Touch Me that could be worn on the chosen position of the body and the vibrotactile stimulation could be actuated by care-givers remotely[29] and a further device Squeeze me which is a

vest with pneumatic compression to create a holding sensation meant to be helpful during panic attacks[29]. GoodVibe is a soft sleeve generating dynamic vibration patterns around the arm alleviating stress (e.g. decreased heart rate) [30]. Huggy Pajamas enables remotely communicating emotional support in the form of "hug" between parent and child[31]. Some devices are already commercially available. Squease[32], a lightweight, inflatable vest applies pressure to the upper body when needed, to calm people with sensory difficulties. Doppel, a device that creates a silent, heartbeat vibration on the inside of wrist has shown to have calming effect during socially stressful situation[33]. Haptic stimulation could provide an alternative intervention for anxious or distressed patients such as those receiving radiotherapy for head and neck cancer who may suffer claustrophobia[4,6]. Despite the interesting potential of many haptic technologies[29-33,] we need to consider the acceptance to patients and the applicability to the radiotherapy environment due to the size and position of the wearable devices.

The sensory qualities of different types of touch stimulation generated by haptic devices (actuators) have also been brought to the emergent research agenda. Although the majority of touch stimulation is realised by employing a vibrotactile motor, it has been found that this may not be the best actuator for affective touch sensation, instead of pleasant feelings, high frequency vibrations can induce negative sensations[34]. Researchers have been experimenting with alternative actuators which may generate more pleasant touch sensations, such as air[35], friction[36], heat[37], textured surface[38], pneumatic and soft robotics[38-41]. A soft brush attached to a robotic hand has been widely used to apply CT-optimal affective touch in psychological studies and has the potential to be made into affective touch haptic device, as mentioned above. Zheng[40] and Wang et al[41] postulate that soft robotic actuators using pliable and skin-like surface textures and controllable pressure have great potential for generating affective tactile touch. This technology could provide an opportunity for empathetic touch to have a more realistic human like sensation.

We see benefits from affective haptic devices on several fronts. First the felt sensation of the physical stimulation may merit positive psychological effect[8,24-26]. Secondly, the digital system enables devices to be remotely controlled and administered. Thirdly the remote administration enables families and carers to connect and communicate support via such remote touch. Regardless of the actual sensory quality of the physical stimuli, the remote physical presence of family and caregivers itself is a source of psychological positivity to an isolated patient.

OPPORTUNITIES & CHALLENGES

Opportunities:

There is an opportunity to provide a non – invasive intervention that can be remotely administered from the linear accelerator control area, and at the same time provide the remote physical presence of quasi human contact. This means that there is limited risk of interpersonal touch - (remove the stress from patients on interpreting the intention of the touch) and concurrently enable a non-contact intervention that could be beneficial during pandemics such as COVID-19.

Challenge:

The promising potential is not without challenge. On one hand, much of the haptic technology is still in the proof-of-concept stage without sufficient evidence to determine effectiveness. Moreover, the restrictions of the radiotherapy environment make the implementation of haptic technology a challenge. The acceptability of new interventions has to be explored in patients, radiation therapists and service providers.

CONCLUSION

This commentary was inspired from the doctoral research to develop comfort interventions in radiotherapy and the development of affective haptic touch technologies. We envision the opportunities and challenges for tactile touch technology to supplement human empathetic touch during radiotherapy. In clinical practice radiation therapists greet their patients with

empathy; there is a dearth of literature targeting empathetic touch in radiotherapy. However the effective use of string for children to maintain empathic contact with parents had shown promising findings[12], therefore the above envisioned haptic technologies for adults could also benefit children receiving radiotherapy. Empathetic touch generated by haptic technologies may equally suit procedures like magnetic resonance imaging, with relatively long scanning times in isolation, providing similar patient benefits. We would like to motivate radiation therapists to develop human empathic touch interventions in clinical practice, and to seek available technology that deploys empathetic tactile touch when available to improve patient comfort.

References

1) Folkert MR, Timmerman RD. Stereotactic ablative body radiosurgery (SABR) or stereotactic body radiation therapy (SBRT).Adv Drug Deliv Rev. 2017;15(109):3-14.

2) The Royal College of Radiologists (RCR), Society and College of Radiographers,Institute of Physics and Engineering in Medicine.On target: ensuring geometricaccuracy in radiotherapy. London: RCR. 2008. 11-4.

3) Dawson LA, Balter JM. Interventions to reduce organ motion effects in radi-ation delivery.Semin Radiat Oncol. 2004; 14(1):76-80.

4) Goldsworthy S, Mundy K, Latour JM. A focus group consultation round exploring patient experiences of comfort during radiotherapy for head and neck cancer.J Radiother Pract. 2016;15(2):143-9.

5) Elsner K, Naehrig D, Halkett GKB, Dhillon HM. Reduced patient anxiety as a result of radiation therapist-led psychosocial support: a systematic review. J Med Radiat Sci. 2017;64(3):220-231.

6) Nixon JL, Cartmill B, Turner J, Pigott AE, Brown E, Wall LR, Ward EC, Porceddu SV. Exploring the prevalence and experience of mask anxiety for the person with head and neck cancer undergoing radiotherapy. J Med Radiat Sci. 2018;65(4):282-290.

7) Goldsworthy S, Palmer S, Latour JM, McNair H, Cramp M. A systematic review of effectiveness of interventions applicable to radiotherapy that are administered to improve patient comfort, increase patient compliance, and reduce patient distress or anxiety [published online ahead of print, 2020 Mar 31]. Radiography (Lond). 2020;S1078-8174.

8) Peled-Avron L, Levy-Gigi E, Richter-Levin G, Korem N, Shamay-Tsoory SG. The role of empathy in the neural responses to observed human social touch. Cogn Affect Behav Neurosci. 2016;16(5):802-813

9) Kolcaba K, Tilton C, Drouin C. Comfort Theory: a unifying framework to enhance the practice environment. J Nurs Adm. 2006;36(11):538-544.

10) Guy JB, Bard-Reboul S, Trone JC, et al. Healing touch in radiation therapy: is the benefit tangible?. Oncotarget. 2017;8(46):81485-81491.

11) Bolderston A. Patient Experience in Medical Imaging and Radiation Therapy. J Med Imaging Radiat Sci. 2016;47(4):356-361.

12) Engvall, G., Ångström-Brännström, C., Mullaney, T., Nilsson, K., Wickart-Johansson, G., Svärd, A. M., Nyholm, T., Lindh, J., & Lindh, V. It Is Tough and Tiring but It Works--Children's Experiences of Undergoing Radiotherapy. PloS one. 2016; 11(4), e0153029.

13) Bruhn JG. The doctor's touch: tactile communication in the doctor-patient relationship. South Med J. 1978;71(12):1469-1473.

14) Choi SM, Lee J, Park YS, Lee CH, Lee SM, Yim JJ. Effect of verbal empathy and touch on anxiety relief in patients undergoing flexible bronchoscopy: can empathy reduce patients' anxiety?Respiration 2016;92(6):380-8.

15) van Erp JBF, Toet A. Social touch in human–computer interaction. Frontiers in Digital Humanities. 2015; 2 (2), 1-14.

16) Durana, Carlos. 'The Use of Touch in Psychotherapy: Ethical and Clinical Guidelines'. Psychotherapy: Theory, Research, Practice, Training. 1998; 35 (2), 269–80.

17) T. Nguyen, R. Heslin, and M. L. Nguyen, "The meanings of touch: Sex differences," J. Commun.1975; 25 (3), 92–103.

18) J. T. Suvilehto, E. Glerean, R. I. M. Dunbar, R. Hari, and L. Nummenmaa, "Topography of social touching depends on emotional bonds between humans," Proc. Nat. Academy Sci. United States America. 2015; 112 (45), 811–816.

19) McGlone, Francis, Johan Wessberg, and Håkan Olausson. 'Discriminative and Affective Touch: Sensing and Feeling'. Neuron. 2014; 82 (4), 737–55.

20) Olausson, H., Y. Lamarre, H. Backlund, C. Morin, B. G. Wallin, G. Starck, S. Ekholm, et al. 'Unmyelinated Tactile Afferents Signal Touch and Project to Insular Cortex'. Nature Neuroscience. 2002; 5 (9), 900–904.

21) McGlone, Francis, Ake B. Vallbo, Hakan Olausson, Line Loken, and Johan Wessberg. 'Discriminative Touch and Emotional Touch'. Canadian Journal of Experimental Psychology = Revue Canadienne De Psychologie Experimentale. 2007; 61 (3),173–83.

22) Morrison, India. 'ALE Meta-Analysis Reveals Dissociable Networks for Affective and Discriminative Aspects of Touch'. Human Brain Mapping. 2016; 37 (4), 1308–20.

23) Löken, Line S., Johan Wessberg, India Morrison, Francis McGlone, and Håkan Olausson. 'Coding of Pleasant Touch by Unmyelinated Afferents in Humans'. Nature Neuroscience. 2009; 12 (5), 547–48.

24) Triscoli, Chantal, Ilona Croy, Susann Steudte-Schmiedgen, Håkan Olausson, and Uta Sailer. 'Heart Rate Variability Is Enhanced by Long-Lasting Pleasant Touch at CT-Optimized Velocity'. Biological Psychology. 2017; 128, 71–81.

25) Mohr, Mariana von, Louise P. Kirsch, and Aikaterini Fotopoulou. 'The Soothing Function of Touch: Affective Touch Reduces Feelings of Social Exclusion'. Scientific Reports. 2017; 7 (1), 13516.

26) Lönsson, Emma H., Kalle Kotilahti, Juha Heiskala, Helena Backlund Wasling, Håkan Olausson, Ilona Croy, Hanna Mustaniemi, et al. 'Affective and Non-Affective Touch Evoke Differential Brain Responses in 2-Month-Old Infants - ScienceDirect'. NeuroImage. 2018; 169 (1), 162–71.

27) Sreelakshmi, M, and Subash TD. 'Haptic Technology: A Comprehensive Review on Its Applications and Future Prospects'. Materials Today: Proceedings, International Conference on Computing, Communication, Nanophotonics, Nanoscience, Nanomaterials and Nanotechnology. 2017; 4 (2), 4182–87.

28) Eid, M. A., and H. Al Osman. 'Affective Haptics: Current Research and Future Directions'. IEEE Access. 2016; 4, 26–40.

29) Vaucelle C, Bonanni L, Ishii H. 'Design of Haptic Interfaces for Therapy'. ACM Press, 2009; 467.

30) Kelling C, Pitaro D, and Jussi Rantala. 'Good Vibes: The Impact of Haptic Patterns on Stress Levels'. In Proceedings of the 20th International Academic Mindtrek Conference, 130–136. AcademicMindtrek '16. New York, NY, USA: ACM, 2016.

31) Teh, James Keng Soon, Adrian David Cheok, Roshan L. Peiris, Yongsoon Choi, Vuong Thuong, and Sha Lai. 'Huggy Pajama: A Mobile Parent and Child Hugging Communication System'. In Proceedings of the 7th International Conference on Interaction Design and Children. IDC '08. New York, NY, USA: ACM, 2008; 250–257.

32) Squasewear. Squease. 2020. Available at www.squeasewear.com/ [Accessed: 24 July 2020]

33) T. Azevedo, Ruben, Nell Bennett, Andreas Bilicki, Jack Hooper, Fotini Markopoulou, and Manos Tsakiris. 'The Calming Effect of a New Wearable Device during the Anticipation of Public Speech'. Scientific Reports. 2017; 7 (1), 2285.

34) Kaaresoja, T., and J. Linjama. 'Perception of Short Tactile Pulses Generated by a Vibration Motor in a Mobile Phone'. In First Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems. World Haptics Conference. 2005; 71–72.

35) Obrist, Marianna, Sriram Subramanian, Elia Gatti, Benjamin Long, and Thomas Carter. 'Emotions Mediated Through Mid-Air Haptics'. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. CHI '15. New York, NY, USA: ACM, 2015; 2053–2062.

36) Bianchi, M., G. Valenza, A. Greco, M. Nardelli, E. Battaglia, A. Bicchi, and E. P. Scilingo. 'Towards a Novel Generation of Haptic and Robotic Interfaces: Integrating Affective Physiology in Human-Robot Interaction'. In 2016 25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN). 2016; 125–31.

37) CUTECIRCUIT. 'The HugShirt™'. 2020. Available at www.cutecircuit.com/the-hug-shirt/ [Accessed: 10 April 2014].

38) Hu, Y., Z. Zhao, A. Vimal, and G. Hoffman. 'Soft Skin Texture Modulation for Social Robotics'. In 2018 IEEE International Conference on Soft Robotics (RoboSoft). 2018; 82–87.

39) ParkY-W, Hwang S, and Tek-Jin Nam. 'Poke: Emotional Touch Delivery Through an Inflatable Surface over Interpersonal Mobile Communications'. In Proceedings of the 24th Annual ACM Symposium Adjunct on User Interface Software and Technology. UIST '11 Adjunct. New York, NY, USA: ACM. 2011; 61–62

40) Zheng, C.Y. 'Affective Touch with Soft Robotic Actuators - A Design Toolkit for Personalised Affective Communication'. In Workshop: Reshaping Touch Communication: An Interdisciplinary Research Agenda, ACM CHI Conference on Human Factors in Computing Systems. Montreal, 2018.

41) Wang KJ, and Zheng CY. 'Toward a Wearable Affective Robot That Detects Human Emotions from Brain Signals by Using Deep Multi-Spectrogram Convolutional Neural Networks (Deep MS-CNN)'. In 2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). 2019; 1–8.

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