Towards Ontologies for Technology in Mental Health Interventions

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Abstract

The mental health care sector has been slow to adopt technology. However pressure on services from worsening mental health trends and a pressing need to develop innovative approaches to improved services has led to increased activity in this area. This paper discusses potential uses of ontologies in the development of interactive systems to support mental health interventions. Different aspects of the domain that may be modelled using ontologies are discussed and initial work in the development of an ontology based system is described. The paper also notes the importance and benefits of incorporating risk management into ontology based systems for this domain.

1 Introduction

In 1996 Harvard University in cooperation with the World Health Organisation and the World Bank published the results of a large international study entitled 'The Global Burden of Disease' [1]. The study revealed that mental illnesses, including suicide, are the second leading cause of disability and premature mortality in developed countries. Cardiovascular conditions come first and all malignant diseases, including cancer, come third. Combined mental illnesses account for over 15% of the total burden of disease in established market economies, such as Europe and the US, and major depression is the single leading cause of disability worldwide among persons over the age of five. Unfortunately several large scale international studies also conclude that the majority of people suffering mental health disorders do not receive the required treatment [2, 3]. The primary causes of failure to receive treatment are lack of access to appropriate specialist services, social stigmas associated with mental health disorders and the difficulties many vulnerable groups (e.g. adolescents and young men) experience in engaging successfully with traditional treatments.

To date there has been limited use of technology in supporting mental health interventions. However pressure on services from worsening mental health trends has led to increased activity in this area. A review of previous uses of technology in mental health is given in [4]. In many cases technology has been used to replicate traditional therapeutic strategies e.g. electronic contact as a natural extension of face-to-face dialogue and the computerisation of self-help materials. Such approaches have demonstrated initial promise in increasing access to specialist services. As the level of involvement by researchers from technical disciplines (e.g. HCI) has increased, recent years have seen a growth in the use of more media rich and interactive systems. For example there is a substantial body of research on the use of virtual reality based exposure therapies, while uses of computer gaming and multimedia storytelling have emerged more recently [5]. These more media rich and interactive systems have demonstrated initial benefits in helping people to engage more effectively with professional services.

This paper discusses how ontologies may play a valuable role in the development of interactive systems which can support mental health interventions. Section 2 discusses several potential uses of ontologies. Section 3 describes different elements of the MHC domain that may be modelled. Section 4 discusses initial work in the development of an ontology based system and notes the importance of risk management in such systems.

2 Uses of Ontologies

This section highlights several potential uses of ontologies in the design and development of interactive systems to support mental health interventions. There is a degree of overlap in the examples identified and it is envisioned that ontologies developed to support one example will be reusable in the development of other examples.

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2.1 Psychoeducation

Psychoeducation is aimed at helping persons with a mental illness, to access information about their illnesses in a clear and concise manner. It can also support clients in accessing and learning strategies to deal with mental illness and its effects. Psychoeducation is not a treatment, but often forms part of an overall treatment plan. It is an important element of improving client efficacy. Recent years have seen a dramatic growth in the number of websites providing psycho-educational information, although the standard varies widely and this variation is a cause for concerns amongst many mental health professionals. In other educational areas there are large bodies of research which demonstrate the benefits and use of adaptive and ontology based systems in the delivery of learner-centred educational materials, e.g. [6]. Such systems have not yet been explored in a psychoeducational context.

2.2 Shared peer content and stories

Telling and reflecting on personal stories is a fundamental element of most, if not all, talk-based mental health interventions. Within some approaches, e.g. Narrative Psychotherapy, the telling and retelling of personal stories in a therapeutically structured manner is the core element of the therapeutic process [7]. Such approaches developed out of movements in psychology by theorists such as Bruner who argued that storytelling represents a fundamental human means of personal understanding and that personal narratives are central to a person's sense of self [8].

Alongside the benefits of telling personal stories, many mental health interventions highlight the benefits of shared stories. For many people experiencing mental health difficulties the shared stories of peers who have experienced similar difficulties can provide valuable emotional support, can help people in understanding that their difficulties are not unique and can create a more accessible context in which to discuss their own difficulties. Stories from peers about the techniques and factors that helped them can help in motivating other people, can help them in understanding therapeutic techniques and can provide them with role models for how to overcome or better manage their own difficulties.

Many mental health interventions will seek to create a record of the client's story. Traditionally this record has be written, however multimedia systems now offer greater scope for media rich records. The Working Things Out (WTO) project explored a therapeutic process in which eleven adolescents worked with therapists to create multimedia narratives about the difficulties they had faced and how they overcame them [9]. The stories created by these adolescents are now used as a therapeutic resource to help other adolescents experiencing similar difficulties.

In the future, increasing amounts of stories/content used in MHC settings may be derived from peers. Alongside stories such as those created by the WTO project, further examples of sharable content include postings on online support forums and discussions groups [10, 11], content generated through the use of mobile storytelling and life-mapping systems [12], and the content of email counselling sessions between therapists and clients. The effectiveness of sharing such content will, to a large degree, be dependent on how effectively content can be classified, and then shared in an appropriate manner with a given client. Shared stories are only useful if they can be used in ways with encourage positive therapeutic change. Some aspects of this classification will relate explicitly to context – a client will find material from someone with a similar background and experience more engaging. However models of treatments and the approaches favoured by MHC professionals also need to be accommodated. Perhaps most challenging of all, are the very strong requirements on delivering content which will not be detrimental to the therapeutic process. For example, content which will be helpful for one client may be harmful to another. It is also important that appropriate content be delivered at a given stage of a treatment process, e.g. content which reinforces the current aims of treatment. There is also a need to avoid repeating content, and deliver a mix of material in order to maintain engagement. The issue of risk management in ontology based systems is discussed in Section 4.1.

2.3 Adaptable systems

Several recent projects have demonstrated the benefits of adaptability in interactive systems for MHC settings. [13] describes a system which allows therapists to tailor questionnaires and homework plans which clients can then interact with on multiple devices. The AKQUASI system [14] has demonstrated initial benefits of allowing clinicians to tailor questionnaires, treatment schedule plans and scoring/evaluation algorithms, based on a palette of predefined functions, input elements and psychometric instruments. Other research has focused on adaptation in more media rich systems. Initial research on the development of VR environments that can be adapted in real time to elicit specific emotional reactions or induce specific emotional states in a user is described

in [15]. The use of embodied conversational agents is discussed in [16, 17]. PlayWrite is a system which allows MHC professionals to create and adapt 3D computer games which can then be used on adolescent interventions [18]. PlayWrite built on initial research in the development and evaluation of a specific computer game Personal Investigator (PI) [5]. Used with appropriate clients PI was found to deliver benefits including helping to establish effective client-therapist relationships and assisting in improving client engagement. However specific social and cultural features, such as the appearance of characters and the accent and language used in game voiceovers, were found the limit the suitability and even make PI unusable with many adolescent clients. Similarly the use of a specific intervention approach limited the suitability of the game for use by a broad variety of therapists. To overcome these difficulties PlayWrite provides MHC professionals with the means of adapting games provided by the system. Using the system MHC professionals have been able to create games which implement a wide range of theoretical approaches to talk-based MHC, address a broad variety of specific disorders and also target the needs of specific social groups.

To date much of the adaptation in the systems noted above is controlled directly by MHC professionals. If effective ontologies can be developed it is possible that greater amounts of system controlled adaptation may be possible. Again the issue of risk management in such systems is discussed in Section 4.1 below.

2.4 Coordinated support

The potential of ontology based systems to coordinate support in chronic patient care across multiple health care professionals and to enable increased support from informal care givers (e.g. family and friends) is discussed by [19]. A 'social context ontology' incorporating both formal and informal helpers is described. Similar requirements exist in the MHC domain. As discussed in section 3.4 below, people seeking help for mental health difficulties may interact with many different MHC professionals, each with different areas of expertise and levels of responsibility in overall service provisions. Given the pressure on existing professional resources there has also been an emphasis of trying to maximise the use of informal support. Difficulties with social isolation and in maintaining social networks are common amongst people with mental health difficulties. Systems which can assist in coordinating support across multiple care providers, both formal and informal, and help clients to manage social networks are likely to prove very helpful in the MHC domain.

The ability to act as an adjunct to face-to-face treatments, and to increase the amount of support provided in diverse contexts and in non-health care settings, e.g. at home or using mobile devices, is another proposed benefit of increased use of technology in a mental health interventions [4, 13, 20]. Computer supported treatments have been shown to decrease the amount of face-to-face contact time required between therapists and clients. They have the advantage of reducing the cost of delivering MHC services, reducing the pressures on professional resources and also offering clients increased flexibility in the delivery of services. Again the ability of ontology based systems to support and effectively coordinate such services may prove very helpful.

3 Ontologies for mental health care

In this section we discuss some of the key aspects of the MHC domain for which ontologies will be required, in order to develop systems such as those described in Section 2.

3.1 Clients

The ability to develop models for clients will be a critical factor in the success of ontology based systems. (Note: in the MHC domain the word client rather than patient is generally used to describe a person receiving help.) Empirical studies aimed at identifying common factors in the success levels of mental health interventions have found that 'client factors' (including a client's strengths and resources and those available in the client's environment) are the single largest contributory factor in determining the success of interventions [21]. Therapeutic interventions are most likely to be successful if the therapist engages with the client in a client-centred way. A quality therapeutic process will actively engage the client's participation, by involving their interests, strengths and ideas. Similarly, technologies are most likely to prove effective if they are designed to be client-centred [4].

Fig.1 highlights some of the elements which may be modelled by an ontology for clients. For any individual it is generally agreed that there are several principal contributory factors in the development of mental health disorders: genetic disposition, past life experiences (particularly early life), current life events, physical illness and socio-cultural and economic factors. The social norms of any society have a large influence on what it means to be mentally healthy. Some of the specific socio-cultural issues which affect

MHC include: gender, age, social class, disability, race, culture and ethnicity, sexual orientation and religious or secular assumptions. The social norms of any society will influence the approaches used in the treatment of mental health issues and also the language used to refer to issues in this domain. The ability of interactive systems to deliver support appropriate not just to the difficulties experienced by clients, but also to their cultural backgrounds and past and ongoing life events, is likely to impact the success of systems.

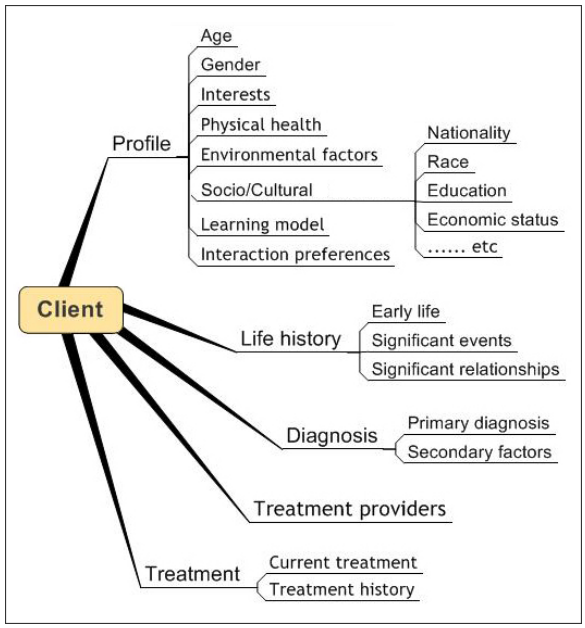

Fig.1 An outline of the elements of a client ontology in the MHC domain

Alongside issues directly related to the nature of the mental health difficulties experienced by clients, Fig.1 notes the potential for elements such as learning models and interaction preferences/requirements to be incorporated into client ontologies. For example research on adaptive learning systems has shown benefits of delivering educational content in a manner appropriate to a person's preferred learning style [22]. Similar client oriented adaptation in systems for psychoeducation is likely to prove beneficial. Modelling interaction needs will also be beneficial. For example evaluations the therapeutic computer game Personal Investigator [5] found that failure to take account of the literacy difficulties of many adolescents experiencing mental health disorders, lead to interaction difficulties, due to the game's reliance on on-screen text and text based keyboard input.

3.2 Mental illnesses

Mental illness refers collectively to all diagnosable mental disorders. Mental disorders are health conditions defined by the experiencing of severe and distressing psychological symptoms, to the extent that normal functioning is seriously impaired, and some form of help is usually needed for recovery. Symptoms may include anxiety, depressed mood, elation, hallucinations, delusions, obsessional thinking or compulsions. Classifications for diagnosing mental health disorders include the DSM IV Diagnostic and Statistical Manual of Mental Disorders and ICD 10 International Classification of Diseases [23, 24]. Common disorders include: depression, anxiety and panic, bipolar disorder, behavioural disorders, obsessive-compulsive disorders, eating disorders, psychosomatic problems, and schizophrenia.

Whilst classifications such as DSM IV and ICD 10 can provide the starting point for the development of machine readable ontologies of mental illnesses, developing such ontologies is a complex task. Alongside classifying the symptoms and difficulties which a person is experiencing, there is a need to classify further issues such as the severity of the difficulty. The NeuroPsyGrid project [25] has initiated research aimed at developing an ontology for one group of mental health disorders, psychosis. The project was initiated based on the recommendations of a series of workshop by the UK National e-Science Centre discussing challenges of data integration in neuroscience and clinical psychiatry research [26]. A stated aim of the project is to work *"towards a common database, a shared metadata model and an ontology of terms for psychosis relevant clinical and biological data"*. Such integration would allow for a more holistic understanding of psychiatric disorders. Whilst the ontology in question is not specifically aimed at supporting interactive systems, the NeuroPsyGrid project has highlighted challenges which must be overcome in developing ontologies for mental health disorders. It is stated that:

> *"The subjective nature of clinical diagnoses and symptom identification is problematic for the development of an ontology, as is the fact that the same symptoms can be associated with different formal diagnoses and treatment recommendations. Another important obstacle to data interoperability in mental health research is the use of different assessments, scales and structured interviews for measuring and recording symptoms and assisting in diagnosis."*

One specific difficulty identified by the NeuroPsyGrid project is that there is currently no

proven means of inter conversion between classifications such as DSM IV and ICD 10. NeuroPsyGrid aims to build on the BIRN Human Brain project, which developed a shared biomedical ontology representing symptoms and disease, but which did not cover concepts in psychiatry.

3.3 Approaches to treatment

Treatments for mental health disorders generally take three forms: (1) talking, listening and learning based treatment (psychological treatment), (2) physical treatment (drugs, ECT, biomedical), and (3) social interventions. In many cases treatment will involve a combination of these three approaches. The examples described in section 2 of this paper focus primarily on the use of ontologies to support listening-and-talking based intervention methods.

As in the case of effectively classifying mental health disorders, modelling the treatment of disorders is again a complex task. One of the greatest challenges involves the sheer variety of theoretical approaches to treatment which exist. Karasu [27] estimated that there are between 250 and 400 different approaches to talk-based treatment and in practice most MHC professionals, even those declaring allegiance to a particular theoretical school, often borrow and mix methods and techniques from various approaches. This borrowing and stitching is formally called eclecticism.

The benefits, or likely success, of attempting to model such a broad range of treatment approaches, or of attempting to model relatively ad-hoc eclecticism, are questionable. Indeed within the mental health research community recent years have seen a push towards Outcome Focused Research [28] aimed at identifying empirically validated treatments, and towards the development of models to help therapists consistently choose appropriate treatment strategies based on the needs of their clients e.g. the Systematic Treatment Selection model [29]. Furthermore, within the large number of approaches identified by Karasu, it is possible to identify a handful of 'major schools' of mental health intervention theories, such as Cognitive Behavioural or Humanistic approaches [30]. Initially it may prove beneficial to develop ontologies targeted at widely use approaches within these major schools, e.g. an ontology of Cognitive Behavioural Therapy (CBT). CBT has the advantage of being more highly structured than many other therapeutic methods and of being applicable to a wide variety of mental health difficulties. Interventions generally follow a specific formulation of assessment, goal setting, attempting specific strategies and then measuring success based on valid and reliable clinical measures (e.g. the Beck Depression Inventory). Ontologies for such approaches may begin by classifying and identifying the relations between assessment tools, various goals and strategies, and the measurements used to quantify outcomes.

Finally alongside the ability to represent different approaches to treatments, ontologies may be required to incorporate further elements including clients' treatment histories and overall models of treatment processes e.g. the stages of a treatment, the intensity of the treatment, the styles of treatment involved (e.g. individual or group treatments), and variations in treatment models from country to country and culture to culture. Again there are models within mental health research which may help in this process. For example, Stepped Care Models attempt to identify different stages of treatments and to provide a decision making framework for treatment delivery based on the intensity of treatment required by different individuals [31].

3.4 Care providers

Alongside clients, the second major user group for any technology designed for the MHC sector will be MHC professionals. Consideration of the needs of this group is critical to the success of technologies [4]. Whilst the overall structure of services varies from country to country, MHC services, particularly public systems, generally consist of multi-disciplinary teams, often incorporating psychotherapists, clinical and counselling psychologists, psychiatrists, counsellors, speech and language therapists and mental health social workers. These frontline services will generally be complemented by further professionals such as general practitioners (family doctors) and community based services including social workers, youth workers, school, college and employment based services, and also NGO's such as the Samaritans.

Some of the aspects of care providers to be modelled include their professional backgrounds and positions within an overall MHC service, their experiences of dealing with different difficulties (e.g. depression), their preferences for using particular approaches to treatment (e.g. CBT) and the client groups with whom they work (e.g. children, adolescents or adults). Other parameters may include availability, access rights to client data, current work load etc.

As noted in section 2.4, people seeking help from mental health difficulties will generally benefit from support provided by informal care givers including family and friends. The inclusion of informal care givers within an overall care provider ontology is likely to prove beneficial.

3.5 Uses of technology

With the introduction of computer supported treatments there will be the need to model the different ways in which computer based services may be used. For example, amongst existing uses of computers in MHC there are standalone systems in which the computer delivers almost the entire psychotherapeutic treatment [32, 33], some in which the computer is used as an adjunct to traditional face-to-face therapy [13, 34], and other in which the computer is only used in face-to-face settings [5]. There is also a need to model the different platforms for delivering services (e.g. desktop services, services provided online and using various mobile devices) and the specific means in which content is delivered on each platform (e.g. in computer games, on discussion forums, in virtual environments, via email etc). Modelling aspects of the context in which services are used will also be important. For example client privacy is considered critical in the delivery of MHC services. Depending on the context of use different technologies will afford differing levels of privacy to clients.

The ability to classify different types of computer based supports and to identify the difficulties, stages of treatments, clients and therapists etc. with which they may prove most effective, will be an important factor in the success and coordinated use of computer supported treatments.

4 Development of Ontologies

The previous sections have discussed potential uses of ontologies and some aspects of the MHC domain that may be modelled in order to develop such systems. At the point of writing preliminary work has been undertaken to develop the basic elements of the described ontologies. The initial focus is being placed on using ontologies to support the integrated delivery of computer supported services and support the sharing of content and resources across multiple platforms and in multiple formats (e.g. in desktop computer games and on mobile devices). One of our aims is to allow end users (MHC professionals and whenever possible people experiencing or with experience of mental health difficulties) to play an active part in the development and elaboration of the ontologies and systems. We also aim to develop ontologies which complement and take advantage of existing classifications within the MHC domain such as those mentioned in Section 3.

The PlayWrite system, briefly discussed in Section 2.3 allows MHC professionals to create and adapt 3D computer games which can then be used in adolescent interventions [18]. The main therapeutic content of games is in the form of dialogues with in-game characters. The PlayWrite system provides a game template and a content creation tool with which MHC professionals can create dialogue based content. Dialogues can be created to include (1) informal conversations, (2) informal question and answer sessions, incorporating a variety of question types in both written and spoken form, and (3) formal psychological questionnaires. Dialogues can also incorporate text based psychoeducational information and variety of different types of media (e.g. images, video and audio files). MHC professionals can adapt games to target a variety of therapeutic issues by creating a series of dialogues and then adding these dialogues to the game template to create new games, fig.2.

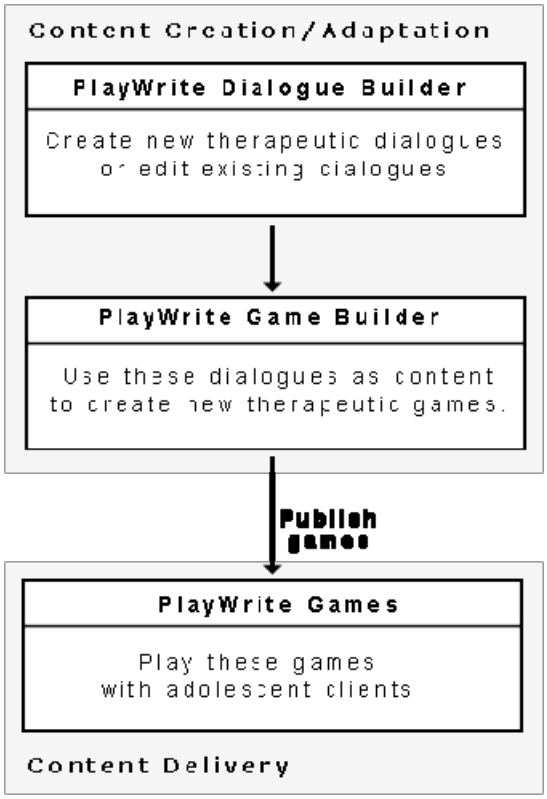

Fig.2 An overview of the PlayWrite system

Initial and ongoing evaluations of PlayWrite have lead to the creation of 15 games – several of which are undergoing detailed clinical evaluations – and a large amount of individual dialogues. These games and dialogues implement a variety of intervention approaches, target a wide variety of disorders and are tailored to the needs of a variety of social and cultural groups. It is envisioned that content and games created

with the PlayWrite system will be shared amongst the community of users.

In initial versions of PlayWrite the content creation tools allowed MHC professionals to create content purely directed at the adolescents who would play the games. In newer versions content tagging and secondary annotation facilities have been added, which encourage MHC professionals to add information that helps to classify content and also provide information that may be helpful to other MHC professionals, e.g. protocols for how games should be used. Content tagging is possible at several levels. For example the overall aims and issues addressed by a game can be tagged, but content can be also tagged at the level of individual dialogues and at a further level down individual pieces of media content can be tagged (e.g. video files or images used within games and dialogues). Tagging is also done with several predefined categories, e.g. therapeutic approach, issue addressed, target client group. MHC professionals have the option of choosing from existing tag lists or creating new tags. New categories can also be suggested.

Alongside the introduction of content tagging PlayWrite is also being expanded so content created with the system can be delivered on multiple platforms. In the initial version content was used only in computer games. Dialogues created with the system can now be delivered in a variety of different forms, including online as simple questionnaires or as interactive dialogues using embodied conversation agents and on a variety of mobile devices. This helps in allowing content created with the system to be used in multiple different contexts. Games are typically used in therapeutic sessions involving a therapist and client. Online and mobile delivery allows clients to access content between sessions. Improving the PlayWrite system to allow MHC professionals to coordinate the integrated delivery of content across multiple platforms is an ongoing aim of the project, as is the exploration of the types of delivery suited to different clients and contexts.

The tagging of content will initially make it easier for MHC professionals to identify games and content that suitable to their own favoured approaches and also appropriate to the clients with whom they are working. As future systems are developed and models for clients, therapists, treatments etc are created, it is hoped that greater degrees of intelligent content retrieval and service delivery will be possible. One of the key factors we are considering in the development of future systems is the issue of risk management.

4.1 Risk management

Any research on or use of technology in MHC settings must meet the strict ethical requirements of the domain. All necessary precautions must be taken to ensure that above all else interventions do not have harmful effects on the client. The Declaration of Geneva of the World Medical Association (WMA) binds MHC professionals with the words: “The health of my patient will be my first consideration” [35]. The WMA Declaration of Helsinki provides ethical guidelines for researchers, and binds all researchers to the agreement that “in medical research on human subjects, considerations to the well-being of the human subject should take precedence over the interests of science and society” [36].

The ability to minimise and manage the risk associated with using technology is critical to meeting the ethical requirements of the MHC domain. Section 2.2 discussed some of the risks associated with systems for sharing peer generated content. Risks included sharing content with a client from whom it is unhelpful or sharing content not appropriate to the current stage of treatment. Other risks to be managed include ensuring any shared information is properly anonymised and that only the appropriate people have access to client information (e.g. managing the access rights of different care providers).

One element of managing risk is to ensure that the development of protocols on how to use a system goes hand in hand with the development of the actual system. Some examples of the issues covered by such protocols might include:

- Identifying the clients for whom a particular system is suitable.
- Describing how the system should be introduced to clients.
- Describing the context in which a system should be used.
- Describing how the use of the system should be monitored.
- Identifying situations in which the use of the system should be terminated.

In the case of ontology based systems it is important that such protocols are embedded within the ontology. In this way the system itself may be able to play an active role in managing any risk.

Fig.3 highlights another way of managing risk. In this case a MHC professional acts as a mediator between computer-based services and a client. They provide input to the system based on their own preferences (e.g. favoured therapeutic approached) and the needs of their client. Based on a matching between available resources/services and models of clients,

MHC professionals, treatments etc, the system can then make suggests to the MHC professionals as to which resources may be helpful for the given client. The MHC professional then makes the final decision as to what services are provided to the client. In this way ontology based systems can support MHC professionals in delivering services to clients.

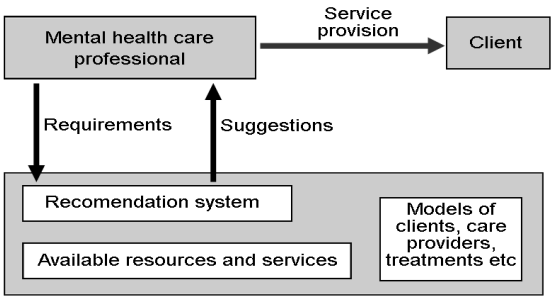

Fig.3 Mental health care professionals manage the services provided to clients

5 Conclusions

Any use of technology in MHC settings raises many ethical concerns, particularly amongst MHC professionals. The use of systems, such as ontology based systems, which include an element of 'intelligence' is likely to raise even greater concern. This paper has discussed several possible uses of ontologies. The uses discussed build on existing practices and movements with the MHC sector. The development of ontologies of this area will be a challenging task, given for example the relatively ad-hoc and eclectic nature of many treatment approaches and the wide variety of MHC professionals and clients with which systems may be used. The ability to manage the risk associated with using ontology based systems will be critical. It is possible however that effectively developed ontologies can actively contribute to managing the risk associated with the use of interactive systems and assist in improving the effectiveness of MHC services.

6 References

[1] Murray, C.L. and A.D. Lopez, eds. *The Global Burden of Disease: A comprehensive assessment of mortality and disability from disease, injuries, and risk factors in 1990 and projected to 2020*. 1996, Harvard University: Cambridge, MA.

[2] Surgeon General, *Mental Health: A Report of the Surgeon General - Executive Summary*. 1999, Department of Health and Human Services: Washington, DC.

[3] World Health Organisation, *Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys.* Journal of the American Medical Association, 2004. 291(21).

[4] Coyle, D., G. Doherty, J. Sharry, and M. Matthews, *Computers in Talk-Based Mental Health Care.* Interacting with Computers, 2007. 19(4): p. 545-562.

[5] Coyle, D., M. Matthews, J. Sharry, A. Nisbet, and G. Doherty, *Personal Investigator: A Therapeutic 3D Game for Adolescent Psychotherapy.* International Journal of Interactive Technology and Smart Education, 2005. 2: p. 73-88.

[6] Devedzic, V., *Education and the Semantic Web.* International Journal of Artificial Intelligence in Education, 2004. 14: p. 39-65.

[7] White, M. and D. Epston, *Narrative means to therapeutic ends*. 1990, New York: Norton.

[8] Bruner, J., *Actual Minds, Possible Worlds.* 1986, Cambridge, MA.: Harvard University Press. 201.

[9] Brosnan, E., C. Fitzpatrick, J. Sharry, and R. Boyle. *An Evaluation of the Integrated Use of a Multimedia Storytelling System within a Psychotherapy Intervention for Adolescents*. Proceedings ACM CHI'06 Conference on Human Factors in Computing Systems. 2006. Montréal, Canada.

[10] Richards, D., *Online Counselling: Trinity College Online Mental Health Community.* British Journal of Guidance and Counselling. (in press).

[11] Houston, T.K., L.A. Cooper, and D.E. Ford, *Internet Support Groups for Depression: A 1-year prospective cohort study.* Journal of Psychiatry, 2002. 159: p. 2062-2068.

[12] Matthews, M., G. Doherty, and J. Sharry. *My Mobile Story: supporting content creation and analysis in mental health interventions*. Proceedings Workshop on Technology in Mental Health at ACM CHI'08 Conference on Human Factors in Computing Systems. 2008. Florence, Italy.

[13] De Sá, M., L. Carriço, and P. Antunes, *Ubiquitous Psychotherapy.* IEEE Pervasive Computing, 2007. 6(1): p. 20-27.

[14] Percevic, R., M.J. Lambert, and H. Kordy, *Computer Supported Monitoring of Patient Treatment Response.* Journal of Clinical Psychology, 2004. 60(3): p. 285-299.

[15] Alcañiz, M., C. Botella, B. Rey, R. Baños, J.A. Lozano, N.L. de la Vega, D. Castilla, J. Montesa, and A. Hospitaler, *EMMA: An Adaptive Display for Virtual Therapy*, in *Foundations of Augmented Cognition*, D.D. Schmorrow and L.M. Reeves, Editors. 2007, Springer Berlin / Heidelberg. p. 258-265.

[16] Bickmore, T. and L. Pfeifer. *Relational Agents for Antipsychotic Medication Adherence*. Proceedings Workshop on Technology in Mental Health at ACM CHI'08 Conference on Human Factors in Computing Systems. 2008. Florence, Italy.

[17] Lisetti, C.L. *Embodied Conversational Agents and Psychotherapy*. Proceedings Workshop on Technology in Mental Health at ACM CHI'08 Conference on Human Factors in Computing Systems. 2008. Florence, Italy.

[18] Coyle, D. and G. Doherty. *Designing Adaptable Technologies for Talk-Based Mental Health Interventions*. Proceedings Workshop on Technology in Mental Health at ACM CHI'08 Conference on Human Factors in Computing Systems. 2008. Florence, Italy.

[19] Paganelli, F. and D. Giuli. *An Ontology-Based Context Model for Home Health Monitoring and Alerting in Chronic Patient Care Networks*. Proceedings Advanced Information Networking and Applications Workshop, AINAW'07. 2007. Ontario, Canada.

[20] Marks, I.M., K. Cavanagh, and L. Gega, *Hands-on Help: Computer-aided Psychotherapy*. 1st ed. Maudsley Monographs 2007: Psychology Press Ltd. 296.

[21] Assay, T.P. and M.J. Lambert, *The Empirical Case for Common Factors in Therapy: Quantitative Findings*, in *The Heart and Soul of Change*, B.L. Duncan, M.L. Hubble, and S.D. Miller, Editors. 1999, American Psychological Association: Washington, DC. p. 23-55.

[22] Kelly, D. and B. Tangney, *Adapting to intelligence profile in an adaptive educational system.* Interacting with Computers 2006. 18(3): p. 385-409.

[23] World Health Organisation, *ICD-10: The ICD-10 Classification of Mental and Behavioural Disorders : Clinical Descriptions and Diagnostic Guidelines* 1992, Geneva: World Health Organisation.

[24] American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*. 2000: American Psychiatric Publishing, Inc.

[25] NeuroPsyGrid. *NeuroPsyGrid - Ontology for Psychosis*. Website, accessed July 2008 at: http://www.neuropsygrid.org/index.php?option=com_content&view=article&id=44&Itemid=27.

[26] Ure, J., R. Proctor, M. Martone, D. Porteous, S. Lloyd, S. Lawrie, D. Job, R. Baldock, A. Philp, D. Liewald, F. Rakebrand, A. Blaikie, C. McKay, S. Anderson, J. Ainsworth, J. van Hemert, and I.S. Blanquer, *Data Integration in eHealth: A Domain/Disease Specific Roadmap.* Stud Health Technol Inform., 2007. 126: p. 144-55.

[27] Karasu, T.B., *The specificity versus nonspecificity dilemma: Toward identifying therapeutic change agents* American Journal of Psychiatry, 1986. 143(6): p. 687-695.

[28] Lambert, M.J., *Psychotherapy outcome and quality improvement: Introduction to the special section on patient-focused research.* Journal of Consulting and Clinical Psychology, 2001. 69(2): p. 147-149.

[29] Beutler, L.E. and T.M. Harwood, *Perscriptive Therapy: a practical guide to Systematic Treatment Selection*. 2000, New York: Oxford University Press.

[30] Feltham, C. and I. Horton, eds. *Handbook of Counselling and Psychotherapy*. 2000, Sage Publications: London.

[31] Bower, P. and S. Gilbody, *Stepped care in psychological therapies: access, effectiveness and efficiency.* British Journal of Psychiatry, 2005. 186: p. 11-17.

[32] Gega, L., I. Marks, and D. Mataix-Cols, *Computer-Aided CBT Self-Help for Anxiety and Depressive Disorders: Experience of a London Clinic and Future Directions.* Journal of Clinical Psychology, 2004. 60(2): p. 147-157.

[33] Proudfoot, J., D. Goldberg, A. Mann, B. Everitt, I. Marks, and J. Gray, *Computerised, interactive, multimedia cognitive behavioural therapy reduces anxiety and depression in general practice: A randomised control trial.* Psychological Medicine, 2003. 33(2): p. 217-227.

[34] Przeworski, A. and M.G. Newman, *Palmtop Computer-Assisted Group Therapy for Social Phobia.* Journal of Clinical Psychology, 2004. 60(2): p. 179-188.

[35] World Medical Association. *World Medical Association International Code of Medical Ethics*. accessed November 2008 at: http://www.wma.net/e/policy/c8.htm.

[36] World Medical Association. *World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects*. accessed November 2008 at: http://www.wma.net/e/policy/b3.htm.