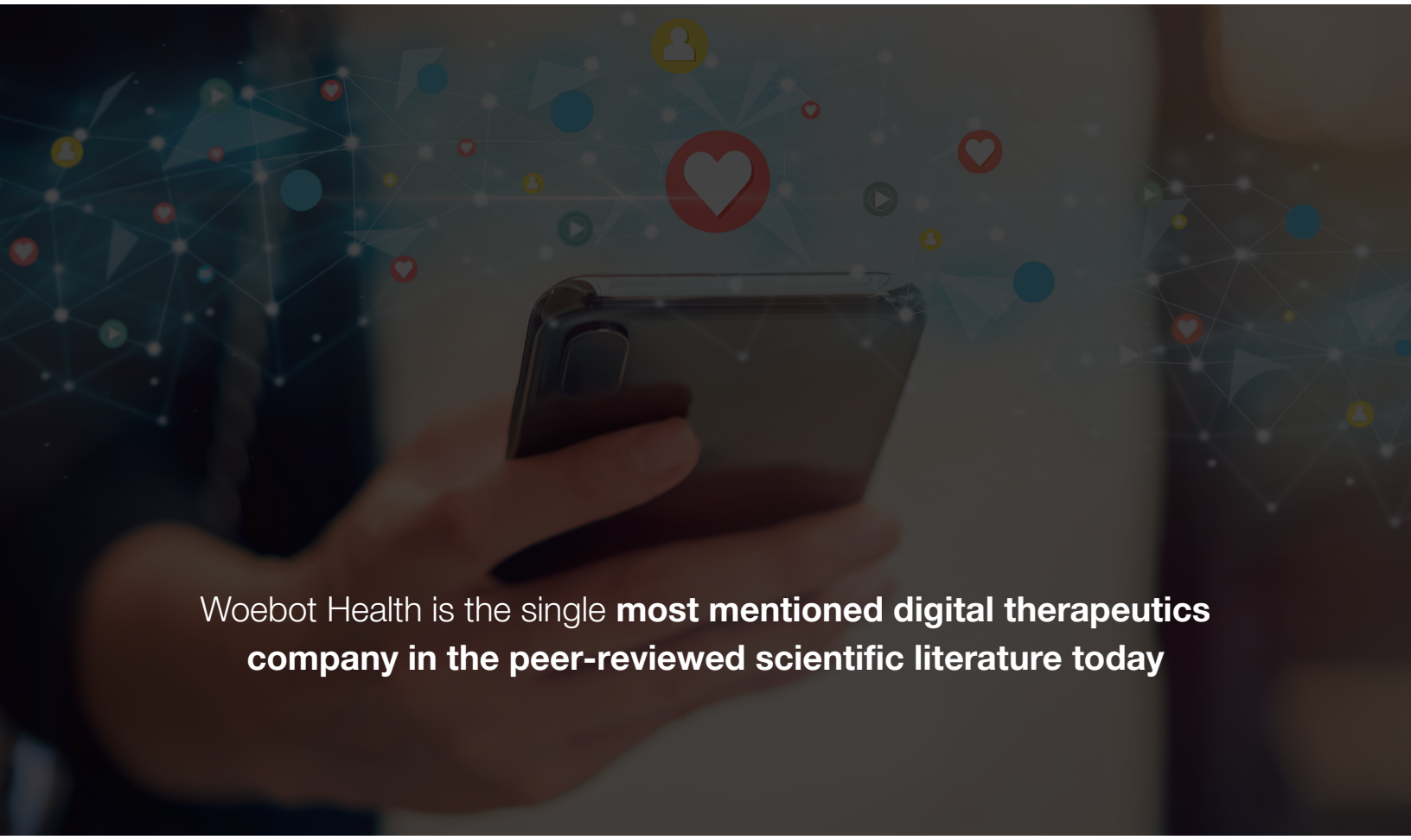
Woebot Health Research

Publications and works in progress

SEPTEMBER 2021



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Peer-reviewed scientific publications

A Randomized Trial of a Therapeutic Relational Agent for Reducing Substance Misuse during the COVID-19 Pandemic

Collaborator: Stanford University School of Medicine

Key points:

- In a randomized clinical trial, use of Woebot-SUD (W-SUD) for 8 weeks resulted in significant reductions in substance use compared with waitlist control.
- Reduction in substance use was associated with better outcomes, including improved mental health.
- Participants who completed high school had the highest overall satisfaction scores and scores on the WAI-SR total scale as compared to participants with college degrees.

Synopsis: This randomized trial compared Woebot-SUDs (W-SUDs) to a waitlist control, for reducing problematic substance use during the pandemic. US adults (N=180, age M=40, 65% female, 68% non-Hispanic white) who screened positive for substance use (CAGE-AID>1) participated. Relative to the waitlist control, the treatment group significantly reduced past-month substance use occasions ($p<.05$) and increased confidence in navigating high-risk situations ($p<.05$). Treatment group improvements in substance use, confidence and cravings were correlated with improvements in substance-related problems and depressive symptoms. Satisfaction with WB-SUD was high, with 96% of lessons rated positively, and 82% of participants indicating that they would recommend W-SUDs.

Citation: *Prochaska JJ, Vogel EA, Chieng A, Baiocchi M, Maglalang DD, Pajarito S, Weingardt KR, Darcy A, Robinson A (2021). A Randomized Controlled Trial of a Therapeutic Relational Agent for Reducing Substance Misuse During the COVID-19 Pandemic. Paper in press at the Drug & Alcohol Dependence journal.*

Evidence of Human-level Bond Established with a Digital Conversational Agent: An Observational Study

Key points:

- The bond that Woebot formed with users, who ranged in age from 18-78 years old, appeared to be non-inferior to the bond created between human therapists & patients.
- The bond is established extremely quickly, in just 3-5 days.
- The bond does not appear to diminish over time.

Synopsis: This cross-sectional, retrospective study of 36,070 users who self-referred to Woebot investigated whether the conversational agent resulted in similar levels of working alliance or "bond" as other CBT modalities. Bond was measured by the Working Alliance Inventory-Short Revised (WAI-SR), and depression was assessed using the 2-item Patient Health Questionnaire (PHQ-2). WAI-SR scores were compared to scientific literature abstracted from recent reviews. Participants ranged in age from 18 to 78 years and 57% reported female gender. Mean PHQ-2 score was 3.03 (SD 1.79) with 55% scoring over the cutoff score of 3 for depression screening. Within 5 days of initial app use, mean WAI-SR score was 3.36 (SD 0.8) with a mean Bond subscale score of 3.8 (SD 1.0) comparing favorably with recent studies from the literature of traditional outpatient individual CBT and group CBT (mean Bond subscale 4 and 3.8, respectively). PHQ-2 scores at baseline were negatively correlated with bond ($r = -0.04$, $p < 0.001$); however, this difference was minimal, with mean scores for all groups above the threshold for 'high' (3.45). Often presumed to be the exclusive domain of human therapeutic relationships, the findings challenge the notion that digital therapeutics are incapable of establishing a therapeutic bond with users. Future research will investigate the role of therapeutic bond as a mediator of clinical outcomes, since boosting engagement and efficacy of digital therapeutics could have major public health benefits.

Citation: *Darcy, AM; Daniels, J; Salinger, D; Wicks, P; Robinson, A. Evidence of Human-level Bond Established with a Digital Conversational Agent: An Observational Study. Journal of Medical Internet Research: Formative Research. Doi: 10.2196/27868*

A Therapeutic Relational Agent for Reducing Problematic Substance Use (Woebot): Development and Usability Study

Collaborator: Stanford University School of Medicine

Key points:

- During the eight week study, substance use occasions were reduced by 30%, cravings decreased by 50%, and confidence to resist urges to use a substance increased 36%.
- Study participants also reported a 21% reduction in symptoms of depression and a 23% reduction in anxiety symptoms.
- Participants demonstrated high scores for Bond on a scale of therapeutic alliance, suggesting that it may mediate outcomes.

Synopsis: This study evaluated the feasibility, acceptability and preliminary efficacy of Woebot adapted for Substance use Disorders (W-SUDs). These adaptations included tracking craving, mood and new content informed by Motivational Interviewing and Dialectical Behavior Therapy. In a single group pre/post design, 101 participants with an average age of 36.8 years, engaged with W-SUDs for 8 weeks. Participants were predominantly female (75%), non-Hispanic white (78%) and employed (72%). About 94% of completed modules were rated positively. Study attrition was relatively high, with about half of participants completing the post-treatment assessment. From pre- to post treatment, confidence to resist urges to use substances

significantly increased (mean score change +16.9, SD 21.4; p<.001), whereas past month substance use occasions (mean change −9.3, SD 14.1; p<.001) and scores on the Alcohol Use Disorders Identification Test-Concise (mean change −1.3, SD 2.6; p<.001), 10-item Drug Abuse Screening Test (mean change −1.2, SD 2.0; p<.001), Patient Health Questionnaire-8 item (mean change 2.1, SD 5.2; P=.005), Generalized Anxiety Disorder-7 (mean change −2.3, SD 4.7; p=.001), and cravings scale (68.6% vs 47.1% moderate to extreme; p=.01) all significantly decreased. Future research will evaluate W-SUDs in a randomized controlled trial with a more diverse sample and with the use of greater study retention strategies.

Citation: *Prochaska J, Vogel EA, Chieng A, Kendra M, Baiocchi M, Pajarito S, Robinson, A. (2021) Outcomes of a Therapeutic Relational Agent for Reducing Problematic Substance Use (Woebot): Development and Usability Study. Journal of Medical Internet Research 2021;23(3):e24850 doi: 10.2196/24850.*

Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial

Collaborator: Stanford University School of Medicine, Dept Psychiatry & Behavioral Sciences

Key points:

- Woebot led to a significant reduction in depression symptoms in 2 weeks compared to an active control group.
- The intervention was highly engaging: participants talked to Woebot almost every day.
- Participants appreciated the process (empathy, accountability, etc.) as well as the content (psychoeducation) of the intervention.

Synopsis: This study evaluated the feasibility, acceptability, and preliminary efficacy of Woebot for college students with symptoms of anxiety and depression. 70 participants aged 18-28 (average of 22.2 years old) were randomized to receive either Cognitive Behavioral Therapy delivered through *Woebot*, a text-based conversational agent (n=34) or to an information-only control group that received an ebook on depression in college students published by the National Institute of Mental Health (n=36). All participants completed standardized measures of Depression (Patient Health Questionnaire; PHQ-9), and Anxiety (Generalized Anxiety Disorder; GAD-7) at baseline and 2-3 weeks later. The majority of participants were female (67%), non-Hispanic (93%) and Caucasian (79%). There were no significant differences between the groups at baseline, and 83% of participants provided follow-up data. Those in the Woebot group significantly reduced their symptoms of depression as measured by the PHQ-9, while those in the information-only control group did not (F=6.47; p=.01). Participants in both groups significantly reduced anxiety as measured by the GAD-7 (F= 9.24; p=.004). This study demonstrated that Woebot is a feasible, engaging, and effective way to deliver CBT.

Citation: *Fitzpatrick KK, Darcy A, Vierhile M. Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational*

Agent (Woebot): A Randomized Controlled Trial. (2017) JMIR Mental Health 4(2). doi: 10.2196/mental.7785.

Acceptability of Postpartum Mood Management Through a Smartphone-based Automated Conversational Agent

Collaborator: Lucile Packard Children's Hospital, Stanford University Hospital & Clinics

Key points:

- This study evaluated the acceptability of Woebot in a large sample of women who had recently given birth.
- Participants reported high levels of satisfaction and acceptability with the 6-week program.

Synopsis: This randomized clinical trial evaluated acceptability and satisfaction with a CBT-based automated conversational agent, *Woebot*, as a postpartum mood management tool. Women (N=192) were recruited and randomized to the chatbot intervention or treatment as usual during their delivery hospitalization. 60% of women indicated child-bearing women face stigma if they seek anxiety or depression services and 93% reported that anxiety and depression are important to monitor during pregnancy and postpartum. 91% of participants reported satisfaction with the 6-week Woebot program. Such programs should be further examined as a postpartum mental health resource.

Citation: *Ramachandran MK, Suharwardy S, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell D, Judy, A. (2020). Acceptability of postpartum mood management through a smartphone-based automated conversational agent. Abstract presented at the annual meeting of the Society of Maternal and Fetal Medicine. February 3-8, 2020.*

Effect of an Automated Conversational Agent on Postpartum Mental Health: A Randomized, Controlled Trial

Collaborator: Department of Obstetrics and Gynecology, Stanford University Hospital & Clinics and Lucille Packards Childrens Hospital

Key points:

- 192 women were randomized to Woebot or treatment-as-usual within 72 hours of giving birth.
- On average, the sample had subclinical scores on baseline measures of postnatal depression.
- Those who had elevated scores demonstrated greater decreases in depression when receiving Woebot relative to treatment-as-usual.

Synopsis: Barriers to postpartum mental health resources include stigma, and limited provider

availability and cost. Automated conversational agents can deliver CBT content through text-based conversations, reducing depression and anxiety symptoms in select populations. This randomized clinical trial sought to examine the effect of a mental health chatbot, *Woebot*, on mood in a general postpartum population. The self-selected sample of 192 women yielded sub-clinical baseline scores, assessed within 72 hours of giving birth, on both the Patient Health Questionnaire and Edinburgh Postnatal Depression Scale. However, among the women with elevated baseline depression scores, trends indicated greater drops in the intervention as compared to the treatment-as-usual group.

Citation: *Suharwardy S, Ramachandran MK, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell D, Judy A (2020). Effect of an automated conversational agent on postpartum mental health: A randomized, controlled trial. Poster presented at the annual meeting of the Society of Maternal and Fetal Medicine, February 3-8, 2020.*

Feasibility, Acceptability, and Preliminary Efficacy of an Automated Conversational Agent for Reducing Problematic Substance Use

Collaborator: Stanford University School of Medicine

Key points:

- Use of Woebot for Substance Use Disorders (W-SUDS), resulted in significant reductions in alcohol use, substance use, depression and anxiety.
- The majority of users rated the program as helpful and would recommend it to a friend.

Synopsis: This study evaluated a therapeutic relational agent designed to reduce problematic substance use. The 8-week program draws upon evidence-based psychotherapies and provides tracking mood and craving, accessing psychoeducational stories, and learning psychotherapeutic skills. Participants demonstrated significant reductions in alcohol use (AUDIT-C, 7.6$\pm$2.1 to 5.6$\pm$3.5), drug use, DAST-10 (5.4$\pm$1.5 to 3.2$\pm$2.6), number of substance use occasions (30$\pm$14 to 21$\pm$18);, and scores on measures of depression (PHQ-8, 10.7$\pm$5.4 to 9.0$\pm$5.4) and and anxiety (GAD-7, 10.4$\pm$5.7 to 8.0$\pm$5.5). 85% of users rated the program as beneficial and 75% said they would recommend it to a friend. With these encouraging findings, future research will evaluate W-SUDs in an RCT with a more diverse sample and greater study retention strategies.

Citation: *Prochaska J, Voguel EA, Chieng A, Kendra M, Baiocchi M, Pajarito S, Robinson A. (2021). Feasibility, Acceptability, and Preliminary Efficacy of an Automated Conversational Agent for Reducing Problematic Substance Use. Abstract presented at the Society for Behavioral Medicine Conference, April 12-16, 2021*.

Efficacy of an Automated Conversational Agent for Reducing Substance Use During the COVID-19 Pandemic: A Randomized Controlled Trial

Collaborator: Stanford University School of Medicine

Key points:

- In a randomized clinical trial, use of Woebot-SUD (W-SUD) resulted in significant reductions in substance use, substance use cravings, and increased confidence to navigate high risk situations as compared to a waitlist only control group.

Synopsis: The COVID-19 pandemic disrupted access to treatment for substance use disorders (SUDs), while alcohol and cannabis sales increased. This randomized trial compared Woebot-SUDs (W-SUDs to a waitlist control, for reducing problematic substance use during the pandemic. US adults (N=180, age M=40$\pm$12, 65% female, 68% non-Hispanic white) with problematic substance use (CAGE-AID>1) participated. Over the 8-week intervention, treatment participants averaged 747$\pm$646 in-app text messages, rated completed lessons 96% positively, and 82% would recommend W-SUDs. Relative to waitlist, the treatment group significantly reduced past-month substance use occasions ($p<.05$) and increased confidence in navigating high-risk situations ($p<.05$). Moderate-to-extreme craving significantly decreased for treatment (44% to 19%) but not waitlist (43% to 30%) participants ($p<.001$). Treatment group improvements in substance use, confidence and cravings were correlated with improvements in substance-related problems and depressive symptoms.

Citation: *Prochaska JJ, Vogel EA, Chieng A, Baiocchi M, Pajarito S, Robinson A. (2021) Efficacy of an Automated Conversational Agent for Reducing Substance Use. Abstract presented at the Annual Conference of the College on Problems of Drug Dependence (CPDD) June 20-24, 2021.*

Associations between COVID-19 Pandemic-Related Stress & Substance Use Problems

Collaborator: Stanford University School of Medicine

Key points:

- Experiencing worsened mental health symptoms during COVID-19 was associated with more substance use problems and depression and anxiety symptoms.
- Pandemic disruptions may exacerbate pre existing substance use problems.

Synopsis: A better understanding of substance use problems, depressive symptoms, and anxiety during the COVID-19 pandemic among people with problematic substance use can inform intervention efforts needed now and post-pandemic. Participants were recruited between June 25–August 18, 2020 for a randomized trial of Woebot for Substance Use Disorders, a novel digital therapeutic for reducing problematic substance use. Recruitment methods included Qualtrics Research Services, Stanford University listservs, Facebook, and word-of-mouth.

Eligibility criteria were U.S. residence, age 18-65, English literate, owning a smartphone, with past year use of a substance and problematic substance use (CAGE-AID score > 2). Exclusion criteria were history of severe alcohol or drug withdrawal, liver conditions, opioid overdose, psychotic symptoms, past-year suicide attempt, past-year medical problems from drug or alcohol use, opioid use without concurrent medicationassisted treatment, past Woebot use, and pregnancy. Baseline data, used in the present study, were collected prior to randomization. SIP-AD scores were higher among participants who struggled with responsibilities at home (r=.15), had greater mental health impacts (r=.25), had greater personal growth (r=.15), frequented bars (r=.20) or large gatherings (r=.19), and reported more depression (r=.51) and anxiety (r=.43) symptoms (p-values < .05). PHQ-8 and GAD-7 scores were higher among those who struggled with responsibilities at home (r = .30, .28), had difficulty getting necessities (r=.18, .19), had greater mental health impacts (r=.45, .53), and worried more about their children (r =.39, .42) (p values < .05).

Citation: *Vogel E, Chieng A, Robinson A, Weingardt K, Pajarito S, Prochaska JJ. Abstract presented at the Annual Conference of the College on Problems of Drug Dependence (CPDD) June 23, 2021.*

The Potential of Machine Learning and Artificial Intelligence in the Delivery of Cognitive Behavioral Therapy

Synopsis: Machine learning and artificial intelligence are emerging technologies that are increasingly used to evaluate big datasets and collect additional knowledge about an individual's presentation and experience. Technology can quickly detect trends and nuances that might be overlooked by even highly experienced clinicians. Digital tools utilizing machine learning and artificial intelligence are particularly poised to deliver timely summaries of a client's mindset and offer tailored interventions, either facilitated by an expert or a machine. Sophisticated algorithms can help with conceptualizing, assessing, and providing a suite of programs for all levels of care. However, they raise important considerations, including the circumstances in which artificial intelligence can carry out behavioral healthcare tasks as well as or better than humans, implementation challenges that affect large-scale automation of certain aspects of behavioral healthcare, and human-machine interactions in behavioral interventions.

Citation: *Darcy A, Daniels J, Salinger D, Wicks P, Robinson A. Digital Therapeutic Alliance: Is Bond with a Relational Conversational Agent Possible? Symposium to be presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, New Orleans, 2021.*

Manuscripts under review/in press

Associations Between Substance Use Problems and Stress During COVID-19

Collaborator: Stanford University School of Medicine

Key points:

- Data from a Randomized Controlled Trial of Woebot for Substance Use Disorder (W-SUD) (N=180; 65.% women) indicated that worsened mental health symptoms during the Covid-19 pandemic were associated with more substance use as well as depression and anxiety symptoms.

Synopsis: The COVID-19 pandemic has produced major life disruptions and increased stress. This manuscript explored the associations between pandemic-related stress and substance use problems among a sample of individuals participating in an RCT evaluating Woebot for Substance Use Disorders. Participants who struggled with responsibilities at home, had greater mental health impacts, greater personal growth, and frequented bars or large gatherings had higher scores on the Short Inventory of Problems for Alcohol and Drugs scores (all p-values<.05). Participants who struggled with responsibilities at home, had difficulty getting necessities, had greater mental health impacts, and worried more about their children had higher GAD-7 and PHQ-8 scores (all p-values<.05). Additionally, participants who lost a job or income during the pandemic had higher PHQ-8 scores (p=.015). In multivariable analyses, greater mental health impacts were associated with higher SIP-AD, PHQ-8 and GAD-7 scores (all p-values<.05). The study concluded that experiencing worsened mental health symptoms during COVID-19 was associated with more substance use problems and depression & anxiety symptoms. Pandemic disruptions may exacerbate pre-existing substance use problems.

Citation: *Vogel EA, Chieng AC, Robinson A, Parjarito S, Prochaska JJ. Paper accepted and in press at The Journal of Studies on Alcohol and Drugs.*

A Randomized Clinical Trial Investigating the Feasibility and Acceptability of a Digital Therapeutic for PPD

Collaborator: Stanford University School of Medicine

Key points:

- This paper reports on the results of the Randomized Clinical Trial investigating the feasibility and acceptability of Woebot for Postpartum depression (Woebot-PPD).
- 192 women who recently gave birth reported high satisfaction and acceptability with Woebot-PPD.

Synopsis: Postpartum depression (PPD) is the occurrence of a major depressive episode with onset during the third trimester of pregnancy or within the first four weeks following childbirth. The syndrome of PPD impacts approximately 10-20% of women worldwide, although more than 50% have some anxiety and depression symptoms ('baby blues') in the first year following childbirth[14]. The PPD literature indicates that CBT and IPT are preferred psychotherapeutic approaches for women with mild to moderate PPD, yet significant barriers to such treatments limit access for women in need. This manuscript designed the protocol implementation of a randomized clinical trial investigating the feasibility and acceptability of digital therapeutic for PPD, delivered through a fully automated conversational agent, among N=192 women who had recently (within 72 hours) given birth. Participants reported high satisfaction with and acceptability of the 6-week program. Barriers and augments to participant recruitment within a Labor and Delivery Unit will be discussed. Such programs should be further examined as a postpartum mental health resource.

Citation: *Suharwardy S, Ramachandran MK, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell D, Judy A. Manuscript in progress.*

Grant-funded research in progress

Woebot for Substance Use Disorders

Collaborator: Stanford University School of Medicine

Funding Agency: National Institutes of Drug Abuse, Small Business Innovation Research Award

Synopsis: Substance use disorder (SUD) manifests in continuous substance use in the face of significant substance related problems, including cognitive, behavioral as well as physiological symptoms. SUD prevalence is at public health epidemic levels and climbing, yet treatment seeking has plateaued given significant access barriers. Effective, accessible, and engaging intervention modalities for SUD are desperately needed. *Woebot for Substance Use Disorders* (W-SUDs) is a two-phase NIDA-funded SBIR. W-SUDs, a novel digital therapeutic, was developed and is presently being evaluated for feasibility and acceptability in the Phase I (N=104) non-controlled pilot. Phase II will investigate W-SUDs's efficacy compared to an active control condition in a fully-powered randomized clinical trial (N=278). The noteworthy ecological validity of such mobile health initiatives makes the proposed research both warranted and timely with great potential to reach a traditionally underserved population in need of prompt attention.

Status: Phase I pilot was completed in July 2020. Phase II started September 2020. Anticipated completion September 2022. Phase I has yielded one conference abstract (Prochaska et al, Society of Behavioral Medicine) and one published paper (Prochaska et al., 2021 JMIR).

Woebot for Substance Use Disorders: COVID-19

Collaborator: Stanford University School of Medicine

Funding Agency: National Institutes of Drug Abuse, Covid-19 Administrative Supplement to the Parent Grant Small Business Innovation Research Award

Synopsis: Since the initial parent grant award of W-SUDs, and across mere months, Covid-19 became a global pandemic, and users worldwide came to Woebot to discuss it and seek help. The company responded by building and deploying Covid-19 specific programming (W-C19) in March 2020. W-C19 elements have been integrated into W-SUDs; we felt it was timely and appropriate to address users' concerns about the pandemic and demonstrate that Woebot was 'intelligent' to the crisis. Experts expect Covid-19's direct and indirect impact upon individuals with SUDs to be particularly heavy. These individuals often have physical vulnerabilities, which increase the relative risk of death from Covid-19, and face limited health care access --

fundamentally challenging given often comorbid mental illness. Moreover, high rates of housing insecurity hinders compliance with shelter-in- place and social distancing recommendations, thereby increasing contagion risk. This supplemental proposal to the parent grant award, with the timely addition of a randomized controlled trial comparing W-SUDs to a waitlist control (WL), expands understanding of W-SUDs' efficacy whilst investigating Covid-19's impact upon the SUD population. Secular trends of increased substance use are anticipated given Covid-19 stressors (e.g., shelter-in- place, disease concerns, economic strife, under-/unemployment). Hence, the WL condition is essential for testing W-SUDs' efficacy in mitigating these Covid-19 related downstream effects. W-SUDs offers immediate access to a digital therapeutic in a resource constrained, socially distanced healthcare ecosystem for an already vulnerable and underserved population, likely faced with readily growing psychological challenges.

Status: Supplement awarded in June 2020. Completed in October 2020. Supplement has yielded two conference abstracts, one manuscript in press, and one manuscript under active review.

Determining Effectiveness of an mHealth Intervention to Provide Adolescent CBT

Collaborator: Washington University Department of Medicine and Pediatrics

Funding agency: Washington University Institute of Clinical and Translational Sciences

Synopsis: Adolescent depression is common and often debilitating. Many teens may be prescribed antidepressant medications, although families may express hesitancy around medication as a first line of treatment for their child. Research indicates that the optimal treatment typically includes a combination of antidepressant therapy (specifically selective serotonin reuptake inhibitors; SSRIs) plus psychotherapy. *Woebot* is a promising digital therapeutic intervention to deliver CBT to adolescents with depression in the context of primary care management. In collaboration with Washington University, Woebot Labs Inc. will be launching a RCT of *Woebot for mild-moderate depression among adolescents* in the summer of 2020, within approximately 11-13 participating pediatric clinics. This RCT will not only assess the preliminary feasibility and efficacy of the intervention itself, but will also gather valuable feedback qualitative from parents and pediatricians about the use of the digital therapeutic in this population. The goals of the feasibility and acceptability study are to establish the program's utility and feasibility within the primary care ecosystem, as well as to test measurement strategies to inform a more rigorous, fully powered subsequent RCT to evaluate the effectiveness of the program in the primary care management of adolescent depression.

Status: Anticipated completion in 2021.

Woebot for Postpartum Mood Management

Collaborator: Lucile Packard Children's Hospital; Stanford Hospitals and Clinics

Funding agencies:

1. Stanford Society of Physician Scholars
2. Stanford MedScholars Grant
3. Stanford Maternal and Child Health Research Institute

Synopsis: Childbirth is a significant event, accompanied by definitive life changes, including physical, behavioral, psychological and emotional adjustments. Unfortunately, about half of all women report increased anxiety and depression symptoms during the postpartum period however only 20% report these symptoms to their doctors. Worldwide, about 10-20% of women develop the full clinical syndrome of peripartum depression. The American Psychiatric Association's (APA) guidelines for the treatment of women with major depression who are pregnant or breastfeeding indicate psychotherapy without medication as a first line treatment. Cognitive behavioral therapy (CBT) and interpersonal psychotherapy (IPT) are evidence-supported and recommended psychotherapies for PPD. Research on evidence-based therapies translated into digital forms has demonstrated efficacy in reducing symptoms of depression, with enormous potential to scale up access. The purpose of this randomized controlled trial was to evaluate the feasibility and acceptability of a 6-week Woebot for postpartum mood management program among adult women recruited during their birth hospitalization.

Status: RCT completed in 2019. Abstracts presented at the Annual Meeting of The Society of Maternal and Fetal Medicine in 2020. Primary outcomes manuscript presently under review.

Other state of the art research

High-performance medicine: the convergence of human and artificial intelligence

Theme: AI and digital health

Summary: The use of artificial intelligence, and the deep-learning subtype in particular, has been enabled by the use of labeled big data, along with markedly enhanced computing power and cloud storage, across all sectors. In medicine, this is beginning to have an impact at three levels: for clinicians, predominantly via rapid, accurate image interpretation; for health systems, by improving workflow and the potential for reducing medical errors; and for patients, by enabling them to process their own data to promote health. The current limitations, including bias, privacy and security, and lack of transparency, along with the future directions of these applications will be discussed in this article. Over time, marked improvements in accuracy, productivity, and workflow will likely be actualized, but whether that will be used to improve the patient–doctor relationship or facilitate its erosion remains to be seen.

Citation: *Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med 25, 44–56 (2019). https://doi.org/10.1038/s41591-018-0300-7.*

It's Only a Computer: Virtual Humans Increase Willingness to Disclose

Theme: Relational Agents, Virtual Humans

Summary: Virtual humans (VHs) that can develop intimacy with people are now becoming reality. Researchers have successfully incorporated social skills (e.g., active listening, mimicry, gestures) into VH systems. When designed as supportive and ''safe'' interaction partners, VHs may improve clinical interviews by increasing willingness to disclose information. In health and mental health contexts, patients are often reluctant to respond honestly. This paper reports the results of a study in which participants interacted with a VH interviewer and were led to believe that the VH was controlled by either humans or automation. As predicted, compared to those who believed they were interacting with a human operator, participants who believed they were interacting with a computer reported lower fear of self-disclosure, lower impression management, displayed their sadness more intensely, and were rated by observers as more willing to disclose. These results suggest that automated VHs can help overcome a significant barrier to obtaining truthful patient information.

Citation: *Lucas GM, Gratch J, King A, & Morency L-P. (2014). It's only a computer: Virtual humans increase willingness to disclose. Computers in Human Behavior, 37(2014) 94-100.*

Psychological, Relational, and Emotional Effects of Self-Disclosure After Conversations With a Chatbot

Theme: Conversational AI, Chatbot, Human-machine communication

Summary: Disclosure can reduce stress arising from negative experiences, diminish anxiety, and increase negative affect in the short term, which ultimately results in long-term psychological improvement. Disclosure met with support can also improve relational outcomes, enhancing relational closeness and intimacy. A plethora of studies have found that people form perceptions of computerized agents and humans in the same way, even though people consciously know that computers are machines that do not have human personalities. This experiment examined downstream effects after emotional versus factual disclosures in conversations with a supposed chatbot or person. The effects of emotional disclosure were equivalent whether participants thought they were disclosing to a chatbot or to a person. This study advances current understanding of disclosure and whether its impact is altered by technology, providing support for media equivalency as a primary mechanism for the consequences of disclosing to a chatbot.

Citation: *Ho A, Hancock J, Miner AS. Psychological, Relational, and Emotional Effects of Self-Disclosure After Conversations With a Chatbot. J Commun. 2018;68(4):712-733. doi:10.1093/joc/jqy026.*

Conversational Agents and Mental Health: Theory-Informed Assessment of Language and Affect

Abstract: A study deployed the mental health Relational Frame Theory as grounding for an analysis of sentiment dynamics in human-language dialogs. The work takes a step towards enabling use of conversational agents in mental health settings. Sentiment tendencies and mirroring behaviors in 11k human-human dialogs were compared with behaviors when humans interacted with conversational agents in a similar-sized collection. The study finds that human sentiment-related interaction norms persist in human-agent dialogs, but that humans are twice as likely to respond negatively when faced with a negative utterance by a robot than in a comparable situation with humans. Similarly, inhibition towards use of obscenity is greatly reduced. We introduce a new Affective Neural Net implementation that specializes in analyzing sentiment in real time.

Citation: *Miner A, Chow A, Adler S, Zaitsev I, Tero P, Darcy A, Paepcke A.(2016). Conversational Agents and Mental Health: Theory-Informed Assessment of Language and Affect. In Proceedings of the Fourth International Conference on Human Agent Interaction (HAI '16). Association for Computing Machinery, New York, NY, USA, 123–130. DOI:https://doi.org/10.1145/2974804.2974820.*

An embodied conversational agent for unguided internet-based cognitive behavior therapy in preventative mental health: Feasibility and acceptability pilot trial

Background: Recent years have seen an increase in the use of internet-based cognitive behavioral therapy in the area of mental health. Although lower effectiveness and higher dropout rates of unguided than those of guided internet-based cognitive behavioral therapy remain critical issues, not incurring ongoing human clinical resources makes it highly advantageous.

Objective: Current research in psychotherapy, which acknowledges the importance of therapeutic alliance, aims to evaluate the feasibility and acceptability, in terms of mental health, of an application that is embodied with a conversational agent. This application was enabled for use as an internet-based cognitive behavioral therapy preventative mental health measure.

Methods: Analysis of the data from the 191 participants of the experimental group with a mean age of 38.07 (SD 10.75) years and the 263 participants of the control group with a mean age of 38.05 (SD 13.45) years using a 2-way factorial analysis of variance (group × time) was performed.

Results: There was a significant main effect (P=.02) and interaction for time on the variable of positive mental health (P=.02), and for the treatment group, a significant simple main effect was also found (P=.002). In addition, there was a significant main effect (P=.02) and interaction for time on the variable of negative mental health (P=.005), and for the treatment group, a significant simple main effect was also found (P=.001).

Conclusions: This research can be seen to represent a certain level of evidence for the mental health application developed herein, indicating empirically that internet-based cognitive behavioral therapy with the embodied conversational agent can be used in mental health care. In the pilot trial, given the issues related to feasibility and acceptability, it is necessary to pursue higher quality evidence while continuing to further improve the application, based on the findings of the current research.

Advantages of virtual agents over clinical psychologists during comprehensive mental health interviews using a mixed methods design

Background: The use of Virtual Agents (VAs) is currently a popular topic in mental health interviews. Advantages of VA over Real Expert (RE) in the interview were reported. However, the advantages of audio-visual VAs over REs during comprehensive mental health interviews remain unclear, and their clarification is important to promote the practical application of VAs in these settings.

Methods: To explore the advantages, we triangulated data using mixed methods design, aiming to show quantitative advantages of the VAs in their perceived rapport and eye movement, and to describe the qualitative advantages of the VAs in their disclosed mental

symptoms during the interview. A total of 55 Japanese university students participated in comprehensive mental health interviews conducted by the VA and RE.

Results: Findings show that participants perceived rapport and moved their right eyes more often, along with disclosing numerous mental symptoms, with the RE than the VA. However, they disclosed more sex-related symptoms to the VA than the RE. The VA can be used most practically in sex-related health fields. The anonymity conditions in the VA setting might be relevant to patients' self-disclosure of sex-related topics.

Embodied conversational agents in clinical psychology: a scoping review

Background: Embodied conversational agents (ECAs) are computer-generated characters that simulate key properties of human face-to-face conversation, such as verbal and nonverbal behavior. In Internet-based eHealth interventions, ECAs may be used for the delivery of automated human support factors.

Objective: We aim to provide an overview of the technological and clinical possibilities, as well as the evidence base for ECA applications in clinical psychology, to inform health professionals about the activity in this field of research.

Methods: Given the large variety of applied methodologies, types of applications, and scientific disciplines involved in ECA research, we conducted a systematic scoping review. Scoping reviews aim to map key concepts and types of evidence underlying an area of research, and answer less-specific questions than traditional systematic reviews. Systematic searches for ECA applications in the treatment of mood, anxiety, psychotic, autism spectrum, and substance use disorders were conducted in databases in the fields of psychology and computer science, as well as in interdisciplinary databases. Studies were included if they conveyed primary research findings on an ECA application that targeted one of the disorders. We mapped each study's background information, how the different disorders were addressed, how ECAs and users could interact with one another, methodological aspects, and the study's aims and outcomes.

Results: This study included N=54 publications (N=49 studies). More than half of the studies (n=26) focused on autism treatment, and ECAs were used most often for social skills training (n=23). Applications ranged from simple reinforcement of social behaviors through emotional expressions to sophisticated multimodal conversational systems. Most applications (n=43) were still in the development and piloting phase, that is, not yet ready for routine practice evaluation or application. Few studies conducted controlled research into clinical effects of ECAs, such as a reduction in symptom severity.

Conclusions: ECAs for mental disorders are emerging. State-of-the-art techniques, involving, for example, communication through natural language or nonverbal behavior, are increasingly being considered and adopted for psychotherapeutic interventions in ECA research with promising results. However, evidence on their clinical application remains scarce. At present, their value to clinical practice lies mostly in the experimental determination of critical human

support factors. In the context of using ECAs as an adjunct to existing interventions with the aim of supporting users, important questions remain with regard to the personalization of ECAs' interaction with users, and the optimal timing and manner of providing support. To increase the evidence base with regard to Internet interventions, we propose an additional focus on low-tech ECA solutions that can be rapidly developed, tested, and applied in routine practice.

Computer-Controlled Virtual Humans in Patient-Facing Systems: Systematic Review and Meta-Analysis

Background: Virtual humans (VH) are computer-generated characters that appear humanlike and simulate face-to-face conversations using verbal and nonverbal cues. Unlike formless conversational agents, like smart speakers or chatbots, VH bring together the capabilities of both a conversational agent and an interactive avatar (computer-represented digital characters). Although their use in patient-facing systems has garnered substantial interest, it is unknown to what extent VH are effective in health applications.

Objective: The purpose of this review was to examine the effectiveness of VH in patient-facing systems. The design and implementation characteristics of these systems were also examined. Methods: Electronic bibliographic databases were searched for peer-reviewed articles with relevant key terms. Studies were included in the systematic review if they designed or evaluated VH in patient-facing systems. Of the included studies, studies that used a randomized controlled trial to evaluate VH were included in the meta-analysis; they were then summarized using the PICOTS framework (population, intervention, comparison group, outcomes, time frame, setting). Summary effect sizes, using random-effects models, were calculated, and the risk of bias was assessed.

Results: Among the 8,125 unique records identified, 53 articles describing 33 unique systems, were qualitatively, systematically reviewed. Two distinct design categories emerged — simple VH and VH augmented with health sensors and trackers. Of the 53 articles, 16 (26 studies) with 44 primary and 22 secondary outcomes were included in the meta-analysis. Meta-analysis of the 44 primary outcome measures revealed a significant difference between intervention and control conditions, favoring the VH intervention (SMD = .166, 95% CI .039-.292, P=.012), but with evidence of some heterogeneity, I2=49.3%. There were more cross-sectional (k=15) than longitudinal studies (k=11). The intervention was delivered using a personal computer in most studies (k=18), followed by a tablet (k=4), mobile kiosk (k=2), head-mounted display (k=1), and a desktop computer in a community center (k=1).

Conclusions: We offer evidence for the efficacy of VH in patient-facing systems. Considering that studies included different population and outcome types, more focused analysis is needed in the future. Future studies also need to identify what features of virtual human interventions contribute toward their effectiveness.

Embodied Conversational Agents for the Detection and Prevention of Suicidal Behaviour: Current Applications and Open Challenges

Background: Embodied conversational agents (ECAs) are advanced computational interactive interfaces designed with the aim to engage users in the continuous and long-term use of a background application. The advantages and benefits of these agents have been exploited in several e-health systems. One of the medical domains where ECAs are recently applied is to support the detection of symptoms, prevention and treatment of mental health disorders. As ECAs based applications are increasingly used in clinical psychology, and due that one fatal consequence of mental health problems is the commitment of suicide, it is necessary to analyse how current ECAs in this clinical domain support the early detection and prevention of risk situations associated with suicidality.

Methods: The present work provides and overview of the main features implemented in the ECAs to detect and prevent suicidal behaviours through two scenarios: ECAs acting as virtual counsellors to offer immediate help to individuals in risk; and ECAs acting as virtual patients for learning/training in the identification of suicide behaviours. A literature review was performed to identify relevant studies in this domain during the last decade, describing the main characteristics of the implemented ECAs and how they have been evaluated. A total of six studies were included in the review fulfilling the defined search criteria.

Conclusions: Most of the experimental studies indicate promising results, though these types of ECAs are not yet commonly used in routine practice. The identification of some open challenges for the further development of ECAs within this domain is also discussed.

The Personalization of Conversational Agents in Health Care: Systematic Review

Background: The personalization of conversational agents with natural language user interfaces is seeing increasing use in health care applications, shaping the content, structure, or purpose of the dialogue between humans and conversational agents.

Objective: The goal of this systematic review was to understand the ways in which personalization has been used with conversational agents in health care and characterize the methods of its implementation.

Methods: We searched on PubMed, Embase, CINAHL, PsycInfo, and ACM Digital Library using a predefined search strategy. The studies were included if they: (1) were primary research studies that focused on consumers, caregivers, or health care professionals; (2) involved a conversational agent with an unconstrained natural language interface; (3) tested the system with human subjects; and (4) implemented personalization features.

Results: The search found 1958 publications. After abstract and full-text screening, 13 studies were included in the review. Common examples of personalized content included feedback, daily health reports, alerts, warnings, and recommendations. The personalization features were implemented without a theoretical framework of customization and with limited evaluation of its impact. While conversational agents with personalization features were reported to improve user satisfaction, user engagement and dialogue quality, the role of personalization in improving health outcomes was not assessed directly.

Conclusions: Most of the studies in our review implemented the personalization features without theoretical or evidence-based support for them and did not leverage the recent developments in other domains of personalization. Future research could incorporate personalization as a distinct design factor with a more careful consideration of its impact on health outcomes and its implications on patient safety, privacy, and decision-making.

Chatbots and Conversational Agents in Mental Health: A Review of the Psychiatric Landscape

Objective: The aim of this review was to explore the current evidence for conversational agents or chatbots in the field of psychiatry and their role in screening, diagnosis, and treatment of mental illnesses.

Methods: A systematic literature search in June 2018 was conducted in PubMed, EmBase, PsycINFO, Cochrane, Web of Science, and IEEE Xplore. Studies were included that involved a chatbot in a mental health setting focusing on populations with or at high risk of developing depression, anxiety, schizophrenia, bipolar, and substance abuse disorders.

Results: From the selected databases, 1466 records were retrieved and 8 studies met the inclusion criteria. Two additional studies were included from reference list screening for a total of 10 included studies. Overall, potential for conversational agents in psychiatric use was reported to be high across all studies. In particular, conversational agents showed potential for benefit in psychoeducation and self-adherence. In addition, satisfaction rating of chatbots was high across all studies, suggesting that they would be an effective and enjoyable tool in psychiatric treatment.

Conclusion: Preliminary evidence for psychiatric use of chatbots is favourable. However, given the heterogeneity of the reviewed studies, further research with standardized outcomes reporting is required to more thoroughly examine the effectiveness of conversational agents. Regardless, early evidence shows that with the proper approach and research, the mental health field could use conversational agents in psychiatric treatment.

Thought leadership

Conversational Agents in Health Care (Letter to the Editor of JAMA)

Key points:

- Executive leadership from Woebot wrote a letter to the editor in response to an opinion piece calling for independent and additional regulation of conversational agents in health care.
- The authors argue that conversational agents do not need a separate regulatory mechanism because they should be considered in the context of their intended use, for which adequate regulatory mechanisms exist.
- The authors highlight and challenge the implicit suggestion that conversational agents should be considered through the lens of replacing human services, since many are not being used in this way.

Citation: *Darcy A, Robinson A, Wicks P. (2020) Conversational Agents in Health Care. The Journal of the American Medical Association, 2020;324(23):2444. doi:10.1001/jama.2020.21509*

Machine Learning and the Profession of Medicine (JAMA Viewpoint)

Key points:

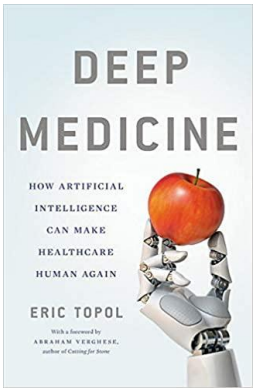
- The world has entered a period of unprecedented innovation, bringing a wealth of possibilities to clinical medicine that amplifies the obligation of the medical profession to serve the human good. Ethical design thinking is essential at every stage of development and application of machine learning in advancing health.
- Physicians with integrity and sophistication should partner closely with computer and data scientists to reimagine clinical medicine. They must also be judicious in their approach to industry relationships so that technology may progress in a manner that upholds the ethical and social trust in medicine.
- Academic physicians must create opportunities for rigorous empirical validation of new innovations against clinical outcomes.
- Leaders throughout medicine must endeavor to create novel ethical approaches sufficient to address emerging dilemmas inherent to use of machine learning technologies in furthering health.

Citation: *Darcy A, Louie AK, Weiss Roberts L. (2016) Machine learning and the profession of medicine. The Journal of the American Medical Association, 315(6): 551-552.*

Does digital mental health need to rethink user engagement?

Summary: Gamification is being hailed as a promising tool within the digital mental health industry. But should the same tactics that are fueling our online addiction become the standard for driving engagement with solutions that are designed to improve our mental health? Our Founder and President Alison Darcy shares her opinion, calling for the field to consider what meaningful engagement means in a digital health context.

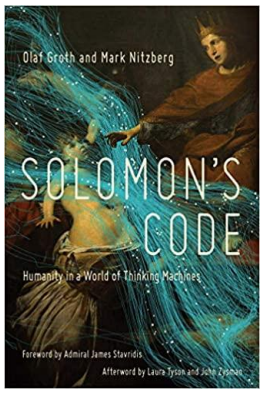
Books that feature Woebot



Deep Medicine: How Artificial Intelligence Can Make Medicine Human Again

Eric Topol, 2019 Basic Books

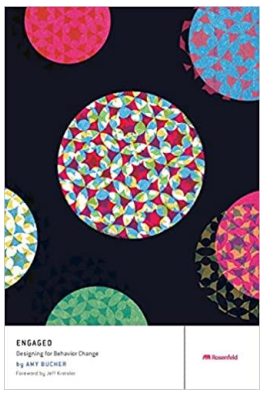
A thoughtful and deep description from leading physician Eric Topol on the ways in which AI can truly unlock the potential of medicine, from deep learning techniques to identifying previously undiscovered tumor features to reinstating a meaningful patient-doctor relationship, to help make medicine better for all the humans.



Solomon's Code: Humanity in a World of Thinking Machines

Olaf Groth and Mark Nitzberg, 2018 Pegasus Books

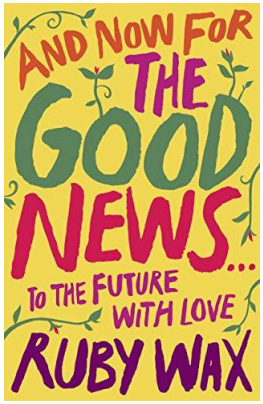
A thought-provoking examination of artificial intelligence and how it reshapes human values, trust, and power around the world.



Engaged: Designing for Behavior Change

Amy Bucher, 2020 Rosenfeld Media

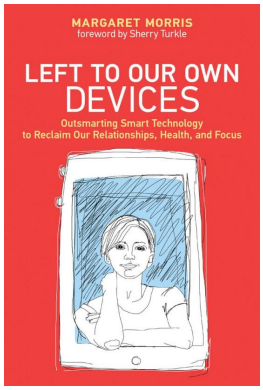
A practical and science-based guide to the best psychological practices in use in digital product design, analyzing both the barriers and levers to achieving behavioral change.



Now for the Good News: To the Future with Love

Ruby Wax, 2020 Generic

How inspiring people spearheading the latest innovation are influencing a brighter future for humanity.



Left to Our Own Devices: Outsmarting Smart Technology to Reclaim Our Relationships, Health, and Focus

Margaret E. Morris, with a foreword by Sherry Turkle, 2018 The MIT Press

Unexpected ways that individuals adapt technology to reclaim what matters to them, from working through conflict with smart lights to celebrating gender transition with selfies.

Additional resources

Industry reports on our category

1. Guide To Improving Wellness With Mobile (2021)

   Publisher: Forrester Research

   Synopsis: Consumers buy wearables, mobile app-based services, or subscriptions to help them to achieve their health or wellness objectives. However, too few services offer enough convenience to consumers to drive substantial, long-lasting changes in health outcomes. The shortcomings of consumer mobile technology aren't the core issue. The services do mitigate friction — just not enough to overcome the difficult task of behavior change. This report focuses on how healthcare and service providers can best make use of today's mobile technology.

2. Global Study: 82% of People Believe Robots Can Support Their Mental Health Better Than Humans (2020)

   Publisher: Oracle (press release)

   Synopsis: The COVID-19 pandemic has created the most stressful year in history and negatively affected the mental health of 78% of the global workforce. 85% of people say their mental health issues at work negatively affect their home. 68% of people would prefer to talk to a robot over their manager about stress and anxiety at work. 76% of people believe companies should be doing more to support the mental health of their workforce.

3. Digital therapeutics | Improving patient outcomes through convergence (2019)

   Publisher: Deloitte

   Synopsis: This article talks about different kinds of digital therapeutic solutions, how they fit into the healthcare journey, potential benefits and challenges facing this industry, and decision making frameworks on putting digital therapeutics into action.

Papers on relational agents

1. Relational Agents in Clinical Psychiatry (2010)

   Theme: Relational agents, Embodied Conversational Agent, Therapeutic alliance

Abstract: Relational agents are computational artifacts, such as animated screen-based characters or social robots, that are designed to establish a sense of rapport, trust, and even therapeutic alliance with patients, using ideal therapeutic relationships between human counselors and patients as role models. We describe the development and evaluation of several such agents designed for health counseling and behavior change interventions, in which a therapeutic alliance is established with patients in order to enhance the efficacy of the intervention. We also discuss the promise of using such agents as adjuncts to clinical psychiatry in a range of possible applications, and some of the challenges and ethical issues in developing and fielding them in psychiatric interventions, before speculating on possible directions for future research on relational agents in healthcare.

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