The future of work and play:
From automated vehicles to working from home

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Abstract

How can technology support workers in our rapidly changing world? How can we help them be productive and creating, and how can we support their overall wellbeing? Our team explores these broad questions for two specific areas: working in future automated vehicles, and working from home. We argue that making progress in these areas will require convergent research - the type of research in which experts from multiple backgrounds create new languages of expression and new approaches that integrate disciplines. In this document we present our own steps towards such a convergent research approach to the future of work and play.

Keywords

Work from home; Automated vehicles; Convergent research

Introduction

Technology holds the promise of allowing us to be more productive than we are today, and at the same time to be able to live happy and healthy lives. We all envision technology-enabled tools that help us to complete tasks quickly and well, to access information when we need it and not be overwhelmed by it, and to efficiently communicate with colleagues throughout the world. We also envision technology-enabled scenarios where work hours might be reduced, where our physical and mental wellbeing are supported, and where we can pursue both work and personal aspirations.

However, it is also clear that these promises of productivity and wellbeing are far from being fulfilled with current technology. Despite the promise of technology, it also threatens to allow work and stress to follow us from the office into the rest of our lives. This is evident in two realms that are familiar to many information workers worldwide: *commuting* and *working from home*.

Commuting is standard practice for millions. In the US, and many other places in the world commuting primarily means *driving* to work. Advances in vehicle automation hold the promise of freeing time drivers spend in their vehicles to work, to engage in other non-driving activities related to relaxation and wellbeing. However, research is needed to create an in-vehicle environment that allows for drivers to engage in non-driving tasks *safely* while the car is driving itself. Critically, such an environment should be designed so that drivers can safely take back manual control of the vehicle when needed (Janssen et al. 2019). Given the current level of vehicle automation, we can expect that drivers will have to take back control fairly often, for relatively long periods, and with relatively short notice. Thus, some of the open research questions include: Which non-driving tasks are appropriate for automated vehicles? How are the opportunities to engage in these activities presented to the driver? Which interaction methods should be used for completing these tasks? And, how to warn drivers that they need to take back control? Our team is exploring all of these questions.

As part of our current efforts to understand workers who drive as part of their commute, we have also gained an understanding of their overall work-related goals and habits over a typical workday. The goal is for technologies that are being considered for automated cars to connect to the overall flow of work and personal tasks for the entire day, including when workers drive to work and when they work at home. This is important given the current situation with the COVID-19 virus. The pandemic has forced large numbers of workers to work from home. While these workers do not drive to work now, their work environment at home has many similarities to the work environment of an automated vehicle (along with many important differences). Specifically, the environment lacks the tools that the worker usually has in the office; it creates a physical separation between the worker and their co-workers; it introduces interruptions (for example the need to attend to children) that workers cannot ignore; and it is an environment where workers seek both personal and work-related activities that enhance wellbeing as well as productivity.

Our team is currently expanding our work from the car to home environments and examining the needs of information workers over an extended time. This includes using a time-use-survey and a conversational agent for data collection. These data will help inform the design of various virtual and augmented reality environments to improve workers' well being, productivity, and satisfaction. The COVID-19 pandemic presents an urgent need to support workers, and provides a unique opportunity to assess systems which support work away from the office while enhancing wellbeing. This will have a lasting impact beyond COVID-19. We see this as a parallel to the way that automated vehicles might push work out of the office in the near future. In this way, COVID-19 is a window into radical change to the work environment and to the stresses that people experience in these work environments.

Exploring work from home

Longitudinal time-use study: A tool to understand the effects of COVID-19

The onset of COVID-19 is forcing a great number of people to work from home on a full-time basis. This sudden and exogenous shift has the potential to cause dramatic effects on workers' productivity and wellbeing, including both mental and physical health. We are adapting a previously designed time-use measurement tool to collect data on time use for a large sample of workers over the course of several weeks of social distancing. These data will provide an accurate and longitudinal measurement of workers' activity, wellbeing, and self-assessed productivity over the course of prolonged social distancing periods.

The research fits within the broader socio-economic literature on time use. As an example, the American Time-Use Survey (ATUS) is one of the primary sources of data in the domain of empirical time use studies (United States Bureau of Labor Statistics, 2019; Krueger, 2009, Krueger, Kahneman, Schkade,Schwarz, and Stone, 2009). Our study expands on the existing literature on the relationship between worker performance of the location of work (Bloom, Liang, Roberts, and Ying, 2015), by providing new insights on the activities of knowledge workers working from home for a prolonged time period for exogenous reasons, rather than by choice.

Conversational agents: A tool for data collection and reflection

We are also complementing the weekly time-use and wellbeing study with a longitudinal *daily* diary-study. The daily diary-study will allow us to gain nuanced and deep insights into workers' goals, challenges, time-use, and wellbeing, with data that is collected *in-situ* at the end of each day. This includes the development and deployment a novel text-based conversational agent (*chatbot app*) for administering a daily diary-study, as well as the design and evaluation of an intervention -- a r*eflection app*, which guides workers in reflecting on their own personal information (collected by the chatbot app), with the goal of increasing wellbeing and work engagement. Our intervention will draw upon the Power of Small Wins (Amabile & Kramer 2011) approach and will also help users to reflect on their emotions and values through the lenses of Emotional Agility (David 2016).

Voice and text-based conversational agents (aka chatbots) are increasingly present in home and car environments, providing natural language user interfaces to a wide range of data and services (Følstad, A. 2017, Brandtzaeg 2018). Everyday tasks supported by chatbots range from shopping, to banking, to playing music and accessing online content (e.g. podcasts). Chatbots are also used to deliver mindfulness, social support and mental health interventions in nonclinical settings, and have shown to provide companionship, emotional and informational support (Moore & Caudill 2019, Griffith et al. 2020). Recent research has found that the use of a text-based chatbot for collecting survey data resulted in higher quality information than using a comparable web-based survey (Kim et al 2019). The conversational interactivity of the chatbot survey reduced satisficing behavior (generating responses that require lower cognitive load

rather than accurate responses), which is often found in self-administered web surveys. Our research will expand on these findings by examining the use of a text-based chatbot to collect data in a *longitudinal* diary-based study.

VR and AR: Tools to enhance productivity, creativity, and wellbeing

Our time-use study and conversational agent study will help us establish and understand pain points in workers' experiences with working from home. Yet, even prior to results which highlight the factors related to workers' pain points, we know in advance that some pain points do exist: not having the tools workers' used to, being lonely, being physically confined to a small (sometimes improvised) working space, and being constantly interrupted. Given this knowledge, we work to enhance wellness and creativity through virtual reality (VR) exposure to natural environments, and through augmented reality (AR) supported meetings.

Spending time in nature can improve health, wellness (Frumkin et al., 2017), and creativity (Palanica, et al., 2019). To receive some of the benefits of being in nature, people do not need to be directly in contact with nature. Viewing nature through a window (Kaplan, 2001; Ulrich, 1984), looking at pictures of nature (Wooller, et al., 2015), and experiencing nature through virtual reality can improve wellness (Wooller, et al., 2018). Annestedt et al. (2013) combined sounds and images and found that the combination outperformed just images in stress promoting recovery. Attention Restoration Theory (ART) (Kaplan, 1995) places an emphasis on natural environments as central to restoring attentional resources depleted by work. Guided by this theory, researchers found that exposure to nature improved creative problem solving (Atchley, Strayer, & Atchley, 2012).

There have also been studies that showcase how AR can transform education (Chen et al, 2016) and the learning space between students and teachers in middle school (Gadille, Impedovo, 2019). These studies have also underscored the need for people who are in isolation to feel a sense of community. The ability to transform the workspace has been heightened given COVID-19 and the need to maintain social distance. Past barriers to wider adoption of these technologies for work include the user experience, ergonomics, and the perception that only younger workers will be accepting of the technology. Some of these challenges have been addressed by recent technology advances including wider field of view, spatial mapping, ease of movement, user controls, gestures, and comfort. However, the use case needs to be defined and tailored for individual jobs, preferences, and environment.

We can assess the effects of AR and VR experiences in multiple ways. This includes measuring all of the participants' wellness using a well-validated and widely used scale, such as the World Health Organization Well-being Index (Topp et al., 2015); using the more comprehensive, such as Scales of Psychological Well-Being (SPW), and using an 84-item self-report questionnaire with six subscales (Autonomy, Environmental Mastery, Personal Growth, Positive Relations With Others, Purpose in Life, and Self-Acceptance)(Urry et al., 2004). We can measure creative problem solving in terms of divergent and convergent thinking. We can assess divergent

thinking with the Alternate Uses Task (AUT) and convergent thinking with the Remote Associates Test of creativity (RAT) (Mednick, 1968). RAT presents three cue words and requires the person to generate the associated word and performance has been established as a valid measure of creativity, and sensitive to nature experiences (Atchley, Strayer, & Atchley, 2012). Additional examples of wellbeing metrics that we will consider are reviewed by Linton, Dieppe, and Medina-Lara (2016). Furthermore, we consider subjective metrics of productivity that relate to an individual's ability to concentrate, work accuracy and expediently (Pransky et al, 2016).

Conclusion

The scientific literature provides a detailed understanding of many aspects of work, but our modern society has never faced the upheaval of a pandemic. This upheaval is profound. First and foremost this is because it makes accepted practices risky and pushes us to find new practices if possible in order to keep workers and the entire population healthy. At the same time the pandemic exposes some of our practices as potentially wasteful and unnecessary relics of the past, opening up opportunities to build better practices. But, there are also plenty of practices that everyone now knows are indispensable - one clear example is school-based education especially for young children.

There is no script for how to handle such a profound upheaval. However, this is a clear call to action for research, and more specifically for what the US National Science Foundation calls convergent research: research that brings together multiple disciplines not just to work side by side, but to create new languages of expression and approaches that integrate disciplines. Our interdisciplinary team draws upon the available findings and literature to improve worker productivity and wellbeing during the pandemic and beyond in the following ways:

1. Time-use-studies: to understand pain points, as well as successes, in working from home.
2. Conversational agents: to get fine-grained data about the daily challenges and successes of working from home.
3. Conversational agents: to support workers as they try to improve both their productivity and their wellbeing.
4. VR experiences: to understand the effects of nature experiences on creativity and overall wellbeing.
5. AR experiences: to enhance inclusiveness and sense of community, and to support workers' productivity, creativity, and wellbeing.

Our work is a step in the direction of convergent research where economics, engineering, artificial intelligence, and human-computer interaction merge to create new ways to work. We conclude with a call for the scientific community to further expand this convergence between disciplines - this is what we need to support the productivity, creativity, and wellbeing of workers during COVID-19 and beyond.

Acknowledgments

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