UNIVERSITY OF CALIFORNIA

Santa Barbara

Sharing a (Cyber)Space:

Fostering Relationship Maintenance in Residential Care through Virtual Reality

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Communication

by

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June 2019

The dissertation of Kathryn Elise Harrison is approved.

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June 2019

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Nicole, you were my academic spouse, my person to call late at night when things didn't make sense, my hero of statistics, and my ray of sunshine. I feel like I hit the jackpot of writing buddies and am so grateful that we were able to go through this journey together as "gritty girls".

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RESEARCH

Journal Articles
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[b]Afifi, T. D., [a]Zamanzadeh, N., Harrison, K.., & [a]Acevedo Callajas, M. (2018). WIRED: The impact of media and technology use on stress (cortisol) and inflammation (interleukin IL-6) in fast paced families. *Computers in Human Behavior, 81*, 265–273. doi: 10.1016/j.chb.2017.12.010

[a]Jayachandiran, S., Harrison, K., [b]Afifi, T.D., & [a]Davis, S. (2016). The United States of wealth: The communicative construction of master and counter narratives of prosperity in the aftermath of the Great Recession. *Narrative Inquiry, 26*, 39-63. doi: 10.1075/ni.26.1.03jay
[b]Streeck, J. & Harrison, K. (2015). Children's interaction in a face-to-face society: The case of a South-American plaza. *Pragmatics and Society, 6*(3), 305-337. doi: 10.1075/ps.6.3.01str
Book Chapters

Harrison, K., [a]Zamanzadeh, N., & [b]Afifi, T. D. (in press). The Impact of Close Relationships on Personal, Relational, and Physiological Health. In Simon Taukeni (Ed.) Psychology of Health - Biopsychosocial Approach. InTechOpen.

[b]Afifi, T. D., Harrison, K., & [a]Zamanzadeh, N.(in press). *Communication, Stress, and Resilience in Close Relationships.* In K. Floyd & R. Weber (Eds.), Handbook of Communication Science and Biology.

[b]Afifi, T. D., [a]Zamanzadeh, N., & Harrison, K. (in press). *Stress, coping, and thriving: The role of interpersonal communication.* In Steve Wilson and Sandi Smith (Eds). Reflections on Interpersonal Communication. Cognella Academic Publishing.

[b]Afifi, T. D., [a]Acevedo Callejas, M, & Harrison, K. (in press). *Resilience through stress: Advancing the Theory of Resilience and Relational Load.* In L. Aloia, J., Crowley, & A. Denes, The Physiology of Interpersonal Communication. Oxford University Press.

[b]Afifi, T. D. & Harrison, K. (2018). *The Theory of Resilience and Relational Load.* In D. Braithwaite, P. Schrodt, and K. Floyd (Eds.) Engaging theories of family communication (2nd ed.). Thousand Oaks, CA: Saige.

Encyclopedia Chapters

[b]Afifi, T. D., [a]Shahnazi, A., & Harrison, K. (2018). Worry and rumination, message recipient psychological characteristics. In Roxanne Parrott (Ed.), *Health and risk messages and processing*. Oxford Press.

[b]Afifi, T. D. & Harrison, K. (2017). The Theory of Resilience and Relational Load. In J. Lebow, A. Chambers, and D. Breunlin (Eds.) *Encyclopedia of Couple and Family Therapy*, 1-5. doi: 10.1007/978-3-319-15877-8_852-1

[b]Pauley, P. M., [a]Veluscek, A., & Harrison, K. (2016). Assortative mating. In A. L. Shehan & M. Duncan (Eds.), *The Wiley Blackwell Encyclopedia of Family Studies* (pp. 133-134). Oxford, UK: Wiley Blackwell. doi: 10.1002/9781119085621.wbefs476

Manuscripts Under Review

Harrison, K., Afifi, T., [a]Zamanzadeh, N. (revise and resubmit). Relationship maintenance as a "booster shot" for families with type I diabetes. Submitted to the Journal of Family Psychology.

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Harrison, K. & [a]Cook-Whearty, M. (2014, March). *Fear appeals: Evaluating stages of change and the target market.* Poster presented at the annual Student Research Symposium, San Diego, CA.

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RESEARCH EXPERIENCE

Research Assistant, The University of Iowa & The University of California, Santa Barbara, Fall 2015-Present

Research Assistant to Dr. Tamara Afifi

- Currently a member of Dr. Afifi's research team tasked with collecting data for multiple projects, both in the field and in the lab.
- Fieldwork includes collecting physiological data in family homes (i.e., saliva, blood, and hair) along with quantitative data (i.e., questionnaires), and qualitative data (i.e., videotaped discussions of stressful conversations)

- Building research skills including statistical analysis (latent variable modeling, regression, growth curve, MLM), ability to communicate complicated concepts clearly and effectively both through writing and oral presentation.

Research Assistant, San Diego State University, Fall 2013-Spring 2015
Research Assistant to Dr. Perry Pauley

- Worked alongside Dr. Pauley in the lab examining the effect of women's hormonal changes (associated with regular menstruation) on their affectionate behavior in committed romantic relationships. We utilized self-report, daily diary, and physiological samples to determine if ovulatory changes were associated with changes in sexual behavior also influence non-sexual affectionate interaction.

Research Assistant, The University of Texas at Austin, Fall 2011- Fall 2013
Research Assistant to Dr. Jürgen Streeck

- Investigated how children participate in public interactions in the plaza, how they acquire interaction skills and personal identity in a South-American plaza. This plaza is the center of public social life of the neighborhood, and it is also the place where many of the neighborhood's children and adolescents socialize every evening.

HONORS AND AWARDS

Top Four Paper, International Communication Association, Interpersonal Communication Division
McCune Dissertation Fellowship award winner, 2018-2019
Nominated for Schoell Graduate Teaching Award, 2018-2019
Top Four Paper, International Communication Association, Interpersonal Communication Division, May 2018, for *Relationship Maintenance as Stress Management in Fast Paced Families* (with T. Afifi, N. Zemanzadeh, & M. Acevedo Callejas)
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Top Four Paper, Western States Communication Association, Health Communication Interest Group, February 2015, for *Much ado about grandparents: Decision making in multi-generational care* (with K. Weichert)
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Associated Students Study Abroad Scholarship ($500), San Diego State University, 2014
President's List, The University of Texas at San Antonio, 2008
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TEACHING EXPERIENCE

Fall 2018, Statistical Analysis (COMM 87), UCSB - TA
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Spring 2017 Introduction to Communication (COMM 1), UCSB - TA
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Spring 2016 Studying Communication: Methods/Critiques (COMM 1305), UI - TA
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PROFRESSIONAL EXPERIENCE

Factor Analysis, The University of California, Santa Barbara, 2018
Communication Expert Panelist, Quantified Communications, 2017-Present
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Structural Equation Modeling, The University of California, Santa Barbara, 2017
Elementary & Intermediate Statistics, The University of California, Santa Barbara 2016-2017
G.I.F.T.S, National Communication Association, Washington, D.C. November 2013 & 2014

PROFESSIONAL AFFILIATIONS

ACM CHI (Association for Computer Machinery, Computer-Human Interaction Group), 2018-Present
International Communication Association, 2017-Present
GSACC (Student Organization), 2016-Present
National Communication Association, 2013-Present

- NCA Women's Caucus Member, 2013-Present

Western States Communication Association, 2013-2016
COGS Member (Student Union - Iowa), 2015-2016
COMGSO Member (Student Organization), 2013-2015

SERVICE TO COMMUNITY

Includes Involvement in Conferences, Meetings, and Professional Organizations:

Paper Reviewer, Journal of Social and Personal Relationships, August 2018
Paper Reader, National Communication Association, Family Communication Division, 2018
Volunteer for the International Communication Association, 2017
COMMTech team member, The University of California, Santa Barbara, 2016-Present
Obermann Center Working Group Member, The Language of Aging, The University of Iowa, 2015-2016
Panel Proposal Reviewer, Western States Communication Association, Health Communication Interest Group, 2016
Panel Chair, Western States Communication Association, Interpersonal Communication Interest Group, 2014

Volunteer for the National Communication Association Conference, 2013, 2014, & 2016
Co-coordinator for the Alumni Banquet Committee, San Diego State University, 2014
Communication Graduate Student Organization, 2013-2015
Treasurer, San Diego, CA
EZCorp, Inc. Volunteer Coordinator, Spring, 2012
Volunteer for Boys and Girls Club, Austin, TX

- Worked with the Executive Director of the EZCORP Foundation, to organize a large-scale volunteer event involving 4 different cross-functional teams (15 people in total) to benefit a local Boys and Girls Club

Communities in Schools, 2009-2010
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- Met weekly with an under privileged child (age 10) to initiate and encourage dialogue about tough day-to-day issues that occurred at school and home
- Pinpointed the specific educational needs of the student and provided support through tutoring and emotional encouragement to inspire future academic success

LANGUAGES

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Data Analysis: SPSS, R, MPlus
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ABSTRACT

Sharing a (Cyber)Space:

Fostering Relationship Maintenance in Residential Care through Virtual Reality

by

Kathryn Elise Harrison

The purpose of this study was to investigate whether a virtual reality intervention could serve as a relational maintenance tool for older adults living in a residential care community. The current study extends the literature on older adults and technology by suggesting that residents can provide one another relational maintenance and communal orientation, which can then potentially help promote such positive outcomes as vitality, social activity, and quality communication, and lessen such negative outcomes as depression, stress, and loneliness. The study took place in a residential care community in Santa Barbara, CA. Residents were randomly assigned to participate once a week for four weeks in either a virtual reality or television group. Analyses were conducted in R and consisted of multilevel mediation with bootstrapping. Results indicate that the virtual reality intervention was positively associated with higher levels of vitality and lower levels of loneliness. The study integrated novel ways of understanding older adults' living in a residential care community, new methodological techniques, and new insights into important relational processes outlined in the theory of resilience and relational load (Afifi, Merrill, & Davis, 2016)

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CHAPTER ONE

INTRODUCTION

The number of adults over the age of 65 is expected to grow to 22% (or about 100 million) of the U.S. population by the year 2060. Today, 811,500 of those older adults live in residential care communities (RCC), or communities in which people can live without requiring a skilled level of care but can no longer live independently (Eckert, Carder, Morgan, Frankowski, & Roth, 2010; Khatutsky et al., 2016). Depending on the circumstances for the move, the transition to an RCC can often feel like "the beginning of the end" for many older adults. This is because human beings have an innate need to feel a connection to others and the move to an RCC can either threaten important, existing social networks or provide new valued networks (Bowlby, 1982; Chen & Schultz, 2016). An added challenge for many older adults is that many of their family members live at a distance from them, making frequent travel to visit the RCC difficult. For most residents, the loss of social network ties with family and friends outside the RCC can damage their access to social support and essential resources, as well as social engagement and life-long attachments (Berkman, Kawachi, & Glymour, 2014; Lubben, Gironda, Sabbath, Kong, & Johnson, 2015). Consequently, building and maintaining other social relationships with residents and staff within the RCC may be essential for residents to thrive (Yorkston, Bourgeois, & Baylor, 2010). Social relationships within RCCs are critical given that older adults' social networks play a key role in their physical and mental health (Rains, 2018; Suls & Rothman, 2004).

Residents in RCCs with diminished social connections are more prone to experiencing loneliness and psychosomatic symptoms, such as depression, which have been shown to increase the risk for mortality (Holt-Lunstad, Smith, Baker, Harris, & Stephenson,

2015; Jansson et al., 2017; Ong, Uchino, & Wethington, 2015). To compensate for some of the changes within social networks outside of the RCC, researchers have found that socializing with others within the RCC can improve physical well-being (Ball et al., 2004; Gleibs, Haslam, Haslam, & Jones, 2011) and life satisfaction (Park, 2009), reduce harmful mental health outcomes such as depression (Lou, Chi, Kwan, & Leung, 2013), and improve overall quality of life (Gleibs et al., 2011).

Virtual reality (VR) is an may be a non-invasive and non-pharmacological tool that could help older adults build and maintain close relationships with other older adults in an RCC. VR, or a "real or simulated environment in which a perceiver experiences presence" in a virtual setting (Steuer, 1992, p. 7) could be an easy and creative way to promote social relationships and a larger sense of community within RCCs. VR has been found to provide numerous benefits for older adults in RCCs, such as stroke rehabilitation (Laver, George, Thomas, Deutsch, & Crotty, 2015; Sposnik et al., 2016), improvements in mobility (Shema et al., 2017), and measurement of episodic memory (Lecavalier, Ouellet, Boller & Belleville, 2018). Little research has been conducted, however, that tests whether VR can improve social relationships for older adults in RCCs. It is possible that residents know and even interact with one another on a regular basis, but the relationships may be superficial. Without quality communication, relational maintenance, and a larger feeling of communal orientation or unity, residents may feel like they are isolated from one another while living right next to each other. VR's ability to fully immerse the user in the virtual world of their choosing, combined with new technology solutions linking together multiple VR headsets, could be a way to allow residents to continue to travel outside the walls of the RCC while building relationships with other residents.

Using the theory of resilience and relational load (TRRL; Afifi, Merrill, & Davis, 2016) as the guiding framework, the purpose of the current study is to examine whether VR can be used as a relationship maintenance tool to connect residents to each other emotionally. VR could function as a relational maintenance tool that helps build emotional connections with other residents over time, reducing the stress and loneliness that may result from living in the RCC. Specifically, there should be improvements in residents' communal orientation, or feelings of unity with other residents against stress (and life's stressors in general), within the RCC as a result of engaging in VR activities together over time. Communal orientation, in turn, could allow residents to improve their quality of communication and social engagement with one another, build a stronger sense of subjective vitality, and reduce negative psychosomatic symptoms, such as loneliness, depression, and stress.

CHAPTER TWO

LITERATURE REVIEW

Social Connection through Virtual Reality

The loss of social connections following the transition into an RCC and its effects on residents' health is a well-documented phenomenon (Berkman & Glass, 2000; Brissette, Cohen, & Seeman, 2000; Thoits, 2011). Globalization has taken many close family members all over the world, making it difficult for them to visit or even keep in frequent contact with their older loved ones (WRVS, 2012). Although the use of information and communication technologies (ICTs) has become common for many older adults in recent years - making it easier for them to communicate with social networks outside of the RCC - there is also evidence that psychological and relational improvement may be highly dependent on how the ICTs are used (Cotten, Anderson, & McCullough, 2013). For instance, Cotten et al. (2013) found only modest improvements in loneliness and no significant change in social isolation for residents who began using the Internet. Other research establishes ICTs as a powerful way for older adults to maintain contact with social networks and lower feelings of loneliness (Chopik, 2016). It is true that access to the Internet allows older adults numerous channels to communicate with friends and family outside of the community. However, many friends and family members of RCC residents may find it difficult to understand their loved one's new circumstances, especially if they are suffering from a serious illness. This lack of understanding can cause friends and family to become distant emotionally and physically,

further intensifying the risk of loneliness and isolation for the older adult (Rains, 2018; Royer, 1998).

Due to the diminishment in connections with one's adult children and other family members upon entry into an RCC, the relationships formed with other residents within the RCC could be crucial to fulfilling resident's social needs. Socialization can often be difficult to initiate because many older adults resist social contact with new networks (Carstensen, 1995). This may be because regulating emotion often becomes more important as older adults age, whereas knowledge acquisition and the desire to meet new people decreases in importance (see the socioemotional selectivity hypothesis; Carstensen, 1995). Even the most social residents still may struggle to engage in meaningful, quality communication with their neighbors. Quality communication between residents can depend on numerous factors, such as institutional influences, perceived rules in the RCC prohibiting talking, and talking rules residents place on themselves (Kaakinen, 1995). Some residents may feel as though they are not allowed to complain, speak to the opposite sex, talk about themselves, or their own loneliness. These perceived unwritten rules have been found to thwart relevant thoughts, emotions, and experiences, making talk between residents severely reduced (Kaakinen, 1992). Additionally, age related function decline, such as hearing loss could severely impede quality communication between residents, causing those without full functional capabilities to lose access to communication opportunities with fellow residents (Pryce & Gooberman-Hill, 2012).

As people age, people tend to be more selective in their friendships (Carstensen, 1995). Shying away from forming new relationships within the RCC, however, does not have to be an inevitable part of aging. Past work has identified two camps of theorizing about the typical desired social relations of older adults – one which says that older adults

attempt to distance themselves from new social relationships (Cumming & Henry, 1961; Gergen, 2012), and one that says that older adults strive to continue engaging in meaningful relationships (McFadden & McFadden, 2014; Rosow, 1967). Years of research since has yielded much more support for the second camp (Holt-Lundstad et al., 2015). It seems that most older adults *want* to be socially and emotionally connected to others but may not have the resources to do so.

In a qualitative study exploring what it means to "successfully age," Reichstadt, Sengupta, Depp, Palinkas, and Jeste (2010) found that older adults identified "engagement with life" and "self-growth" as two of the most important factors. Fowler, Gasiorek, and Giles (2015) argue that aging can be a communicative process that allows people agency over how they age. To age successfully, individuals must embrace their age through continuously building healthy relationships throughout the entire lifespan (Giles, Davis, Gasiorek, & Giles, 2013). Fowler et al. (2015) put forward the communicative ecology model of successful aging or CEMSA. CEMSA states that individuals can control the process of aging through communication by developing an "aging space" in which they can thrive. When individuals feel as though they have the efficacy to manage the growing challenges and changes associated with growing older, they will perceive themselves as aging successfully. Members of the RCC could be an important resource to communicatively address the uncertainties about aging that CEMSA recognizes. Group-based activities utilizing new technology, such as VR, could serve as a mechanism through which new relationships are initiated and maintained (Gleibs et al., 2011; Jang et al., 2014).

Virtual Reality as Recreational Activities in RCCs

Staff members in RCCs actively try to remedy residents' feelings of loneliness and social isolation and promote relational maintenance through group-based recreational

activities (RAs), such as trips or social gatherings. There is much evidence to support that these programs within RCC's can improve physical, mental, and psychological well-being (Human Kinetics, 2010; Leitner & Leitner, 2012; Onishi, Masuda, Suzuki, Gotoh, & Kawarua, 2016; Tinsley & Eldredge, 1995). Although well meaning, many times these activities do not alleviate residents' loneliness or depression. Past research has found that residents reported most RAs to be stereotypical, patronizing, and lacking a challenge (Dobbs et al., 2008; Park, Knapp, Shin, & Kinslow, 2009). Many residents may also feel as though they do not have enough input on the activity, and therefore, it may lack meaning for them (Theurer et al., 2015). Without meaning, many residents may choose not to participate in the activity at all. Although RCC staff have been highly successful in designing and facilitating social activities that are physically active, such as resident-led walking groups (Taylor et al., 2003) or dance (Eyigor, Karapolat, Durmaz, Ibisoglu, & Cakir, 2009; Keogh, Kilding, Pidgeon, Ashley, & Gillis, 2009), residents who are physically limited are still excluded. Furthermore, even with these efforts many RCCs still do not provide communication environments conducive to promoting quality communication between residents (Hickson, Worrall, Wilson, Tilse, & Setterlund, 2005). Using VR as an RA to create meaningful experiences for older adults in RCCs could be one way to fulfill these factors that are so often lost in more traditional RAs.

Virtual reality. One reason VR could be such a powerful activity for older adults is that the synthetic sensory information that VR provides has the ability to make individuals believe as if the environments they are viewing are real (Blascovich et al., 2002). Slater (2018) discusses this affordance as "the real power of VR" (p. 432) stating that, "even though you know it is an illusion, this does not change your perception or your response to it" (p. 432). That is, the highly immersive nature of VR provides a perceptual illusion,

triggering the brain-body system to react, even when the cognitive system acknowledges that what is being seen is not real. This experience of feeling as though one is somewhere else through VR has been defined as *presence* (Pan & Hamilton, 2018; Sheridan, 1992; Usoh, Catena, Arman, & Slater, 2000), whereas the feeling of being there with someone else is called *co-presence* (Casanueva & Blake, 2001; Garau et al., 2003; Pan & Hamilton, 2018). VR allows individuals to see and share relics of their past as well as new experiences, such as using travel videos to simulate both past trips as well as new ones, which could in turn mimic benefits found in reminiscence research (e.g., increased empathy, emotional connections, intimacy, meaning of life; Henkel et al., 2017). These benefits could be further amplified by participating in a new experience alongside another resident. According to Boothby, Clark, and Bargh (2014), sharing a positive, new experience with someone else can actually make that experience more pleasant.

Generally, VR can be divided into three categories: immersive VR, cave VR, and semi-immersive or non-immersive VR. Immersive VR (IVR) consists of a head-mounted device (HMD) containing 3D, stereo vision via two screens, user dynamic control of viewpoint, and surround vision, allowing the user to see only the virtual world. IVR has the ability to make users feel as though they are present and fully interacting with their virtual surroundings (Blascovich & Bailson, 2011; Pan & Hamilton, 2018). Because the brain cannot differentiate between virtual and real experiences, the patterns of neurons that fire when individuals experience a virtual world are nearly identical to experiencing it in the real world (Blascovich & Bailson, 2011). Cave VR typically consists of three to four walls with images projected onto each and the user sitting in the middle of the room. This style of VR provides the feeling of being surrounded by a specific environment. The user also wears glasses; however, they do not fully block out reality (Cruz-Neira, Sandin, & DeFanti, 1993).

Finally, semi-immersive or non-immersive VR display, sometimes called augmented reality, provides a bridge between real and virtual worlds. This form of VR usually only engages between one to three sensory systems (e.g., hearing, vision, scent, and/or touch; Pan & Hamilton, 2018). Regardless of the type of VR chosen, all VR contains hardware (i.e., visual displays and/or motion capture systems) and software. New VR software is constantly being created but is always evaluated using two metrics: interaction dynamics (i.e., no response to fully responsive) and graphical realism (i.e., low to high; Pan & Hamilton, 2018).

Virtual reality and older adults. VR has already been tested with older adults as a solution to many age-related problems. For instance, Mirelman et al. (2016) tested non-immersive VR's ability to act as an intervention targeting mobility and cognitive issues. They found that, with the combination of non-immersive VR and treadmill training, older adults experienced improvements in age-related motor and cognitive deficits. VR has also been successful in balance training, which has been shown to have increased benefits over more typical exercise for older adults (de Vries, Faber, Jonkers, Van Dieen, & Verschueren, 2018). VR has even been suggested as an alternative to pharmacological treatments for Alzheimer's disease. In a case study, Foloppe, Richard, Yamaguchi, Etcharry-Bouyx, and Allain (2018) recruited a 79-year-old woman with early onset Alzheimer's disease. She engaged in virtual and then real cooking tasks for a total of 16 days. They discovered that she was able to relearn some cooking skills in the virtual condition and then transfer those skills to real life. Surprisingly, however, little social research has been conducted that has tested VR's potential to enhance and maintain the social relationships of older adults living in RCCs.

In an exception, Lin, Lee, Lally, and Coughlin (2018) conducted an experiment over two weeks in which 63 assisted living residents used headsets and software created by

Rendever, a small VR company created specifically for older adults living in assisted living communities. Rendever was created by a group of engineers at the Massachusetts Institute of Technology (MIT) AgeLab, with the goal of helping older adults engage in reminiscence therapy, find a sense of purpose through new experiences, and keep in touch with family in a novel way. Rendever's software allows for virtual travel, viewing family photos, and a 360° degree live video. This new virtual reality company is particularly unique because multiple users can interact in the same virtual environment at the same time. For example, if residents want to take a trip to a market in Paris, they can "go there" together, seeing and experiencing the same exact environment, at the same time. Lin et al. (2018) divided residents into two groups who were either exposed to cultural experiences and travel through VR (the experimental group) or who watched television together (the control group). The study revealed that the group who experienced the VR condition showed positive social outcomes such as feeling less lonely and socially isolated, improvements in psychosomatic responses, such as reduced likelihood of experiencing symptoms of depression, and reporting better levels of overall wellbeing. The intervention, however, was relatively short and it was not explicitly focused on fostering emotional connections or a larger sense of communal orientation among residents. Lin et al.'s (2018) research questions were also not theoretically grounded. In the current study, I explore similar outcomes guided by a theory that may be able to help further elucidate the social benefits of VR for groups of residents. Although Lin et al.'s (2018) study provides a preliminary understanding of the potential for VR to be used as a relationship maintenance tool with residents in RCCs, there is still much researchers do not understand about the impact of this technology on residents' mental and relational well-being. For the purposes of this study, I will focus my attention on Rendever's IVR capabilities, using a HMD and software created by Rendever.

Within this virtual space, it becomes easy to see how this technology could present innovative ways for residents in RCCs to create a space for quality communication and social engagement with one another and maintain their relationships by sharing their virtual experiences (Stanney & Hale, 2014). One particularly attractive affordance of IVR in social research is that it provides highly convincing personal, social, and environmental presence for those using it (Pan & Steed, 2017). This could override feelings of resistance in forming and maintaining new relationships through RA, because they may feel as though they have more input on the content they interact with, making the experience more meaningful for them. Further, the ability to co-view and engage with the same IVR in a group of RCC residents could be of particular value to older adults who long to travel but are no longer able. For example, virtual reality gives people with physical disabilities the opportunity to have fully functioning bodies that can take them to the places they could not go otherwise, making it available to people of all abilities to participate together. Immersive environments can create "networked minds," giving people the ability to emotionally connect on a deeper level (Harms & Biocca, 2004).

The Theory of Resilience and Relational Load (TRRL)

IVR could be an innovative tool that can help residents build and maintain important relationships with other residents. According to the TRRL (Afifi et al., 2016), when people actively maintain their relationships over time, it helps them manage the stress that affects their relationship and promotes resilience and potential thriving. Relational maintenance includes daily, prosocial actions, verbal and nonverbal behaviors, and activities people engage in to sustain desired relational states (Stafford & Canary, 1992). IVR activities, as a type of relationship maintenance, should allow older adults to sustain contact with other residents in a novel and exciting way, making them feel more vital. Ryan and Frederick

(1997) define vitality as the "conscious experience of possessing energy and aliveness" (p. 530), and lifespan scholars have used the idea of vitality to explore a wide array of topics related to older adults (Elliot, Gallegos, Moynihan, & Chapman, 2017; Ju, 2017; Visser, Hirsch, Brown, Ryan, & Moynihan, 2015).

The TRRL, along with CEMSA, would argue that maintaining one's social relationships, within the family and with others outside the family, is an important part of successful aging and resilience throughout the lifespan. For friends and family of older adults in an RCC, relationship maintenance could include frequent phone calls and visits, being supportive and sensitive to the resident's changing needs, and understanding the grief that the older loved one may be experiencing as a result of those changing needs. For friendships within the RCC, relationship maintenance could include providing support and empathy, engaging in activities together, and doing something thoughtful for each other.

For many older adults in an RCC, engaging in IVR as a relationship maintenance activity could be a way to create a communal orientation or feeling of unity among residents. Communal orientation is the degree to which people believe they are a team or unified with others in combatting their stressors and life in general (Afifi et al., 2016). The TRRL recognizes that all individuals experience stress, whether the stress is from daily frustrations, such as the difficulty to perform daily tasks, or major life stressors, such as dementia. When individuals use maintenance behaviors, actions, and activities in their relationships over time, they build up emotional reserves, or an "accumulated stock of relationship wealth" (Feeney & Lemay, 2012, p. 2004). These emotional reserves prevent stress, as well as help people manage it when it occurs. When people invest in their relationships through relationship maintenance, it also fosters a communal orientation.

The TRRL builds upon the theory of emotional capital (Feeney & Lemay, 2012), which states that these accumulated emotional reserves can be drawn from during times of stress, such as end of life care (Afifi et al., 2016; Feeney & Lemay, 2012). The TRRL (Afifi et al., 2016) argues that the association between communal orientation and relationship maintenance is bidirectional. Relationship maintenance fosters a communal orientation or sense of unity. When individuals approach their own problems and the problems of others with a communal orientation, however, they also then are more likely to invest in those relationships by maintaining them. This bidirectional relationship will foster resilience or the ability to positively adapt to change and potentially thrive. It may even allow residents to learn something new or grow in one's personal and/or relational well-being, in the face of adversity.

A "we-ness" or "team" mentality (i.e., communal orientation) helps people feel supported and as if they are not alone, which affects the way they feel about their partner/family member and the way they communicate with each other when they are stressed. Stress and resilience are often co-created through communication with others and the experience of the stressor is heavily shaped by communication. When individuals have emotional reserves to draw from during times of stress, they are able to approach the stressor from a broader mindset (see broaden and build theory; Fredrickson, 2001). This ability to appraise the situation and their relational partner with a more benevolent mindset, allows individuals to have more control over negative emotions during conflict, creatively problem solve, engage in fewer attributional errors (i.e., assuming some blame for their stress rather than blaming others), and uplift their partner/family/friend and the relationship (Afifi et al., 2016; Afifi et al., 2018). Conversely, when an older adult is opposed to forming new relationships within their community and becomes lonely (Cornwell, 2011), they will be

more likely to perceive the communication and behaviors of others as social rejection instead of acceptance (Cacioppo & Cacioppo, 2012). A visual representation of the TRRL can be seen in Figure 1.

As stated previously, it is more likely that older adults are not opposed to forming new relationships but rather do not have the resources to form and maintain relationships within the RCC. For instance, relational maintenance within the RCC is often diminished by variables such as functional disability because opportunities for residents to participate in social activities becomes more limited (Jang et al., 2014). Many residents suffer from age-related disabilities, which includes people who begin to experience slow and subtle changes in their communication ability as they age. These problems usually get worse with age and affect important functions, such as the maintenance of social networks (Yorkston et al., 2011). This is alarming when one considers that the benefits of relational maintenance and communal orientation extend past isolated interactions with relational partners and can promote positive, long-term benefits like a reduction in psychosomatic symptoms, such as depression (Jang et al., 2014). By allowing access to residents of all abilities, developing relational maintenance and communal orientation through IVR activities could help promote social connections and alleviate negative mental health symptoms.

It seems undeniable that viewing relationships within the RCC with a communal perspective could help residents feel less alone, which is especially important given the evidence that relationships with the staff and other residents have a strong impact on the resident's quality of life (Henkel, Kris, Birney, & Krauss, 2017). IVR activities may be a particularly successful relational maintenance activity because of the immersion and network capabilities of the technology. Through full immersion, residents experience the presence of a new place, outside of the confines of the RCC. Rendever's unique networking capabilities

create a novel opportunity to experience co-presence in this new environment, which the TRRL predicts will create a sense of personal subjective vitality or feeling of being "alive." The positive emotions and social connections generated from this relational maintenance activity should, therefore, facilitate higher levels of communal orientation, and in turn, quality communication and social engagement between the residents each time the IVR is used. Past research has failed to test IVR's ability to enhance social relationships because the technology lacked sophisticated network abilities. Rendever provides a new possibility that has only been tested once before (Lin et al., 2018). For these reasons, it is likely that relational maintenance through VR could promote cognitive interdependence, which depends heavily on feelings of closeness, trust, and commitment. When residents develop a strong sense of subjective vitality within the RCC, they should also then communicate more positively with each other. Past research has tested the TRRL in the context of marital or dating couples and families, however, they theory has yet to be applied to the aging literature.

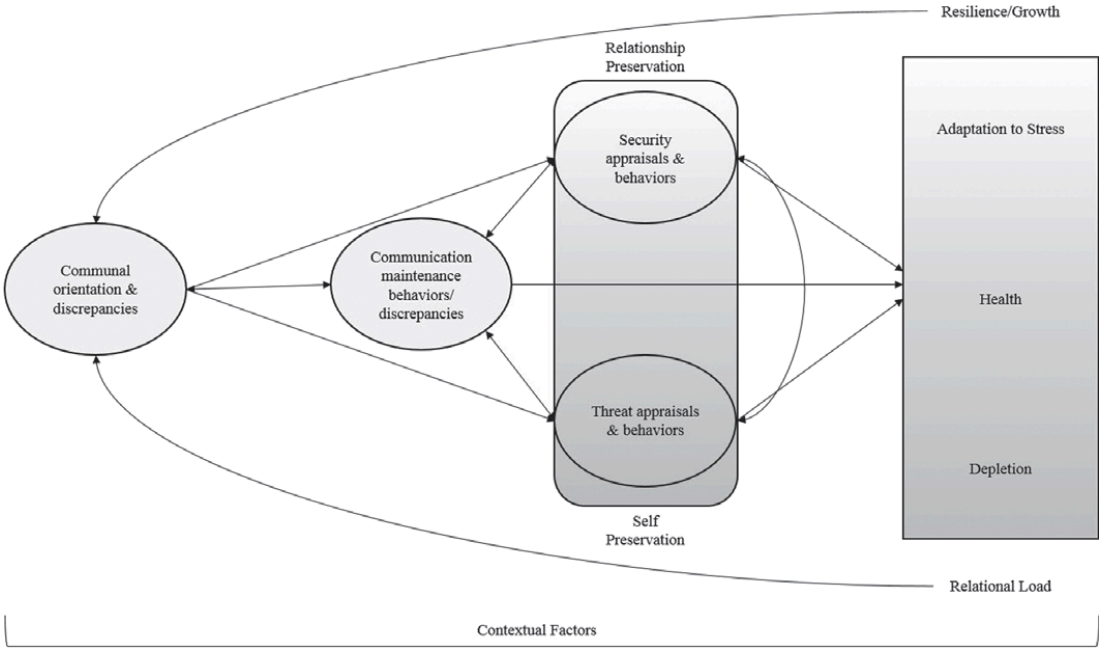

Figure 1. Representation of the theory of resilience and relational load (TRRL; Afifi et al. 2016)

Building Vitality Through Virtual Reality

Along with better quality communication and social engagement between residents, IVR, as a relationship maintenance tool, could also help build a greater sense of communal orientation within the RCC and, in turn, a greater sense of vitality. Through a strong sense of communal orientation, residents will be more likely to maintain and invest in relationships within their RCC (Afifi et al., 2016). As stated previously, RCC staff often integrate different forms of RA into resident's schedules to stimulate socialization, cognitive function, and creative expression (Everard, 1999; Leitner & Leitner, 2012). These RAs may be the only form of socialization a resident receives in any given day and are, therefore, critical for the well-being and vitality of residents. In a review of RAs across 70 articles, including quantitative, qualitative, and observational studies, Plys (2017) found that the top three activities available to residents were family visits, walking, and physical exercise classes. Although these are, inarguably, important activities that should not be replaced, they may be leaving behind residents without family who can visit or those who are much more limited in their physical abilities. This could mean that many RCCs are invisibly divided by those who can participate and those who cannot. Buelow and Fee (2000) illustrated this point when they found that residents who were more functionally able commented that they did not want to participate in many of the scheduled activities with residents with lower functional ability.

For new media and technology to be effective in community building, it must be both useable and accessible to all older adults (Burmeister, Bernoth, Dietsch, & Cleary, 2016). Although there are many examples of useable and accessible ICTs popular with RCC residents (i.e., Ipad, Wii, Internet), they are often lacking the sense of collective immersion

in an environment that could generate excitement and connection within the RCC. The complete sense of presence that IVR offers could be an effective solution to this problem. The immersive nature could provide empathy and emotional support that may be lacking in other close relationships outside of the community (Rains, 2018), but has also felt impossible to find within the community. Connecting with others through new virtual experiences could help residents gain a certain "membership" within their community that was unavailable to them otherwise due to physical limitations. Sharing these new virtual experiences should make residents feel more alive and energetic, even leading them to potentially feel like they are part of something larger than themselves (Haberstroh & Moyer, 2012; Høybye et al., 2005) and united in their approach to their community (Afifi et al., 2016).

Psychosomatic Symptoms of Loneliness

The inability to foster meaningful social connections later in life has also been shown to be associated with highly detrimental health consequences. Behaviorally, lonely older adults are more likely to engage in harmful health practices, such as decreased physical activity, worsened diet, and poor sleep (Hawkley & Cacioppo, 2010). The association between loneliness and sleep is particularly interesting in that it may be a bidirectional relationship – feeling lonely causes one to lose sleep and losing sleep has been found to worsen loneliness (Hawkley, Preacher, & Cacioppo, 2010; Jacobs, Cohen, Hammerman-Rozenberg, & Stessman, 2006). Mental health problems, such as clinical depression may also limit quality communication and communal orientation. Molinari et al. (2009) found that, although a portion of older adults enter RCCs with preexisting mental health issues, many more quickly develop depressive symptoms during the transition into the RCC. This may make it crucial for interventions targeting loneliness in RCCs to reach older adults quickly after their transition into the community. When assisted living residents experience

depression, it could cause them to pull away from their friends and family and doing so promotes increased symptoms of depression (Lou, Chi, Kwan, & Leung, 2013). Some of the most troubling mental health issues that older adults face, such as suicide risk, have been directly correlated with social isolation, loneliness and functional decline (Mezuk, Rock, Lohman, & Choi, 2014). The TRRL (Afifi et al., 2016) argues that prolonged relationship maintenance promotes better relational health, mental health, physiological health, and resilience. Interacting with VR could be a way to overcome the environmental constraints of the RCC and encourage psychological reframing (Ong, Uchino, & Wethington, 2015).

Lonely older adults are also likely to exhibit many adverse physiological reactions, such as neurobiological changes. As people age, they experience age-related changes in the neuroendocrine, cardiovascular, and inflammatory stress response systems, all which can be exacerbated by a lack of meaningful relationships (Cacioppo, Capitanio, & Cacioppo, 2014). Loneliness can also affect cognitive processes such as executive functioning, create a higher sensitivity to social stimuli, and a decrease in trust in interpersonal relationships (Cacioppo & Hawkley, 2009). In a prominent study examining the neurology of loneliness, Cacioppo, Norris, Decety, Monteleone, and Nusbaum (2009) tested the impact of loneliness and social isolation on the brain. fMRI results showed that the participants who were the loneliest did not display as much activity in the ventral striatum, or the brain's reward system, as nonlonely participants.

IVR has already been used with older adults to control memory impairment (Optale et al., 2010), improve mood (Baños et al., 2012), and cognitive training (García-Betances, Jiménez-Mixco, Arredondo, & Cabrera-Umpiérrez, 2015). García- Betances et al., (2010) found that cognitive training through VR blunted behavioral and psychological symptoms for patients with mild cognitive impairment. VR has also been shown to reduce the severity

of depression and self-criticism and increase self-compassion (Contrera et al., 2016), which could be important for older adults who feel uncomfortable or unconfident in their aging bodies. Virtual environments have also been found to decrease sadness and anxiety (Baños et al., 2012), which could lead to increases in vitality. Further, virtual reality could increase RCC resident's sense of presence of others through technologically mediated social interactions, potentially diminishing feelings of loneliness and increasing the sense that the community is "in this together." By engaging in this three-dimensional virtual environment, assisted living residents may begin to feel more comfortable interacting with one another, prompting them to feel more energized within their community and less lonely overall. Therefore, this study hypothesizes that:

H1: Compared to a comparison group (watching the same images on a television), residents who engage in the shared IVR intervention with other residents will experience greater communal orientation, which, in turn, will predict a) higher levels of social engagement, b) better quality communication with other residents c) higher levels of personal subjective vitality, d) less loneliness, b) fewer depressive symptoms, and c) lower levels of stress.

CHAPTER THREE

METHOD

Research Design

Residents in a residential care community completed a baseline survey and then were randomly assigned to either the experimental group using the VR and traveling to various locations and viewing different images together, or the comparison group where they watched the same content but on a television. Residents were scheduled to participant once a week for four weeks on a day that worked with their schedule. At the end of each session, participants in both groups completed a survey and then a focus group discussion.

Participants

Forty-seven residents from a residential care community in Santa Barbara, CA participated in this study. Initially, fifty-five participants were recruited, however due to attrition, the final sample was forty-seven residents. Participants were approximately 82 years old (M = 82.32; range = 54-96, SD = 8.92) and one participant did not disclose his/her age. The sample consisted of 72% women (n = 36) and 28% men (n = 14). In terms of ethnicity, 93% of participants were White/European American (n = 46), but the sample also included 4.1% Asian American (n = 2), and 2% Native American (n = 1). Forty-four percent of participants were married (n = 22), 36% were widowed (n = 18), 14% were divorced (n = 7), and 6% had never been married (n = 3). Of the participants who were not currently married, 10.7% were in a romantic relationship (n = 3). In the group of residents who were either married or in a romantic relationship, 65% indicated that their romantic partner lived with them at the residential care community (n = 15) and 35% indicated that their romantic partner did not reside with them at the residential care community (n = 8). Of the participants with a romantic partner residing with them at the residential care community, 39% indicated

that they were providing care to their romantic partner (n = 9). Residents had lived in their community approximately four years (M = 4.24; SD = 3.15). The majority of the participants (75%, n = 36) had family that lived within an hour driving distance from them.

Recruitment

Participants were recruited from a residential care community in Santa Barbara, CA. This 20-acre community includes independent living, assisted living, and memory care. At full capacity, the community can house 400 residents, although for this study, residents were only recruited from independent and assisted living. The average cost to live at this RCC is approximately $5,945 (range $5,351-6,540) a month, with variation depending on the size of the apartment and care needs. As stated above, the community at this RCC was mainly white/European American, educated, and affluent.

To recruit eligible participants, the executive director of the community announced the study at resident gatherings. The research team, which included myself and several well-trained undergraduate research assistants, also attended resident social hours, classes, and made phone calls to eligible residents, as identified by the community director, director of nurses, and the activities director. The director or staff members informally evaluated the resident's cognitive status using medical records and personal knowledge of the residents. To be eligible, residents could only have mild cognitive impairment (MCI) and could only participant if that MCI did not significantly affect their ability to understand and complete the survey questions.

Residents were also ineligible if they suffered from a history of vertigo, hallucinations, and aggressive behavior (based upon medical records and staff knowledge) that could be made worse by the VR equipment. There were no limitations on physical ability, as participants were seated while using the equipment, which helped to reduce the

risk for vertigo or injury. Once eligible residents were identified, each resident was approached in private and explained the purpose of the study to gather his/her verbal consent to participate. Once verbal consent was obtained, the resident was randomly assigned to a group and then the group was scheduled times to complete the study at the same day and time as a control group.

Of the total 47 participants, 26 completed the VR experimental group and 21 participated in the television comparison group. Of the participants in the VR experimental group, 15 completed all four weeks of the intervention, 9 completed at least three weeks, and 2 completed only two weeks. Of the participants in the television comparison group, 17 completed all four weeks of the study, 3 completed at least three weeks and 2 completed only two weeks. This type of attrition is highly common in studies with this population. Often, research involving older adults can be hindered due to health problems, not demonstrating a clear benefit to the participants, and easy fatigability (Mody et al., 2009).

Procedures

The purpose of this study was to explore how the use of linked VR headsets could provide an affordable way for residents of an RCC to foster and maintain relationships through new virtual experiences. Initially, each group contained $n = 6$ participants, but these numbers shifted as the study progressed to accommodate resident's schedules and needs (range = 3-6 per group).

The residents were assigned to the intervention group or the comparison group. They were scheduled to participate on the same day every week, for four weeks, based on the day that worked best for their schedules. They were asked to come to the activity room in a central location of the RCC. Participants from both groups showed up to the same place but were then separated by a door between the rooms. The participants in the experimental group

were assigned a room with just tables and chairs and the participants in the comparison group were assigned a room with tables, chairs, and a television. On the first week, all of the participants were given an initial survey, meant to measure their baseline. The initial survey took residents about 15 minutes to complete and two residents required the survey to be read aloud to them because of vision issues. Once they completed their first survey, participants then participated in their first study session. In subsequent weeks, participants began their study session with the technology portion and then completed their survey, followed by a focus group discussion (in the intervention and comparison groups). In all, participants completed four survey – one baseline survey and three post surveys following the technology sessions.

Rendever, a small virtual reality company based out of Cambridge, Massachusetts, provided the IVR hardware and software used during the study. As stated above, Rendever's software and hardware were limited during the first tests (Lin, Lee, & Lally, 2018). However, Rendever has since made major improvements (including screen display and resolution), making us confident their equipment would be sufficient to test the outlined constructs. Rendever's hardware consisted of a tablet that controlled all IVR headsets as the activity was underway, and a Samsung GearVR headset and Samsung S7 smartphone for each resident in the experimental group. The phone and headset displayed the same content to all participants in the IVR group, meaning that the headsets synced together and allowed residents to view the same virtual world simultaneously. This was done by placing the mobile phone in the headset and using the tablet to control the content, managed by the research team. The research team then placed the headset on the resident's head to fully cover their eyes and control the content being seen using a tablet. This made the technology more accessible for residents who were not as technologically savvy as is usually required to

operate the program alone. Residents in the comparison group watched the exact same content, but on the television. This was done by casting the content to the television using a Google Chromecast (a small device that allows you to stream content from your device to your television) and the Google Home application on the tablet. After the researchers plugged in the Chromecast into the television, they went into their Google Home account settings and "mirrored" the tablet screen to the television. This allowed the experimental and comparison group to run at the same time.

As stated previously, residents participated with their group in either the experimental VR group or the comparison group at four time points, once a week for one month and viewed new videos each time. Each VR or television session lasted about 12-15 minutes, depending on the week. The researchers used the Rendever application to create playlists of videos that all had a common theme. Themes included "Exotic Animals," "Culture," "Travel," and "Outdoor Experiences" (see Table 1). Their conversations during the experience were audio and video recorded each time and once they finished the technology session, they were asked to discuss their experience. To encourage residents to begin talking during the focus group, they were told, "This is your chance to discuss anything about the experience that we did not ask you on the survey. Let's go around the circle and discuss the following questions. First, how did you feel during the experience? What was your favorite part of the experience? Have you ever had an experience like this without VR or TV? Was there anything that you did not like about the experience?" These conversations were audio and video recorded. Typically, the survey, technology session, and focus groups after each session lasted around 1 hour and 15 minutes. The qualitative data from the focus groups will be analyzed in a separate manuscript.

Control Variables

Along with the demographic information reported above, the baseline survey also measured the residents' amount of time they have lived at the community (M = 4.24 years), the reason they moved (mostly voluntary), their distance away from their nearest family member (M = 2.08 hours), and how often they speak to their closest family member (M = every other day to every few days). Residents were also asked to estimate how many other residents and staff in the RCC they consider close friends ($M_{residents}$ = 6.11, M_{staff} = 2.94), how many of the other residents in their assigned group they know well (M = 1.78) and how many are strangers (M = 1.59).

Measures

Chronic emotional capital. To understand the participants' relational maintenance with other residents in the community and the social climate of the facility, the residents completed Feeney and Lemay's (2012) chronic emotional capital scale. This scale was not directly used to test the hypotheses but instead used for informational and descriptive purposes and to see if the use of the VR changed their perceptions of relationship maintenance by the end of the study. The reduced version of this scale is an eight-item Likert-type scale that asks people to reflect on the relationship maintenance actions, activities and behaviors they received from someone (or in this case, a group of other residents) over the past month and then every week afterward for four weeks. In their baseline survey, residents were asked, "Think about the other residents in your group for this study and indicate how much they have done each of the following actions over the past 30 days." Residents were then be presented with seven items ("complimented me," "smiled at me," "greeted me when I came in the room," "enjoyed seeing me get enthusiastic about something," "said thank you when I did something for him/her," "made me laugh," and "said something that made me feel good about myself"). Residents indicated their answers using

an 8-point scale (0 = not at all; 2 = sometimes; 4 = a great deal). Residents who did not know anyone in their group at baseline were instructed to answer "0 = not at all" on their first survey. Responses to these items were then averaged to form an index of chronic emotional capital (α = .95, *M* = 5.25, SD = 1.33).

Loneliness. Residents' perception of loneliness was measured using the three-item Revised UCLA loneliness scale (Hughes, Waite, Hawkley, & Cacioppo, 2004) on a three-point scale (1 = *hardly ever*, 2 = *some of the time*, and 3 = *often*). The residents were asked to keep in mind their relationships at their residential care community and then were presented with the following items: "How often do you feel that you lack companionship?," "How often do you feel left out?," and "How often do you feel isolated from others?" The loneliness score was the sum of all three items, with higher scores indicating greater loneliness (α = .78, *M* = 3.71, *SD* = 1.23).

Vitality. Ryan and Fredrick's (1997) 7-item measure of vitality was used to measure vitality. Items included statements such as, "I feel alive and vital," "I have energy and spirit," and "I look forward to each new day." Items were measured on a 7-point Likert-type scale ranging from 1 (*not at all*), 4 (*somewhat true*), and 7 (*very true*). Responses to these items were then averaged to form an index of vitality (α = .87, *M* = 5.25, *SD* = 1.33).

Depression. Depression was measured with the 15-item Geriatric Depression Scale Short-Form (Yesavage et al., 1983). Participants were given the instructions: "Choose the best answer for how you felt over the past week" and were asked to indicate "yes," "sometimes," or "no." Sample items include, "Are you basically satisfied with your life?", "Have you dropped many of your activities and interests?", and "Do you feel you're your life is empty?". Responses were then counted and any number above four from the "yes" column indicated depression (α = .81, *M* = 2.28, *SD* = 2.77).

Communal orientation. Eleven items were used to assess residents' perceptions that they respond to stress, and life in general, together as a team with other residents' in the community (see Afifi et al., 2018). Items also assessed if residents' felt as though other residents are looking out for their welfare. (e.g., "I will always get through my stress together with my community in the RCC," "The residents' at the RCC are a team when it comes to how we approach stress that one another face"). The Likert-type items ranged from 1 to 7, with 1 being "strongly disagree" and 7 being "strongly agree." Responses to these items were then averaged to form an index of communal orientation ($\alpha = .81$, $M = 4.70$, $SD = 1.32$).

Quality of communication. The residents were asked to reflect on their communication with the other residents in their group over the past month at baseline and the past week after each session using the Iowa Communication Record (ICR; Duck et al., 1991). The ICR is a 6-item scale with a semantic differential (or bipolar words on either side), with numbers from 1-9 in between (i.e., attentive/poor listening, in-depth/superficial, smooth/difficult, guarded/open, great deal of understanding/great deal of misunderstanding, and free of conflict/laden with conflict). A seventh item was added to measure "emotionally supportive/emotionally unsupportive". The scale overall had an acceptable reliability ($\alpha = .81$, $M = 6.26$, $SD = 1.52$).

Perceived stress. Participants' perceived stress was measured using the four-item Cohen, Kamarch, and Mermelstein's (1983) perceived stress scale (PSS). In the initial survey, they indicated on a 5-point scale, with 0 being never and 4 being very often, how stressed and overwhelmed they felt over the past month and on subsequent surveys they indicated how stressed they had been over the past week. The items included, "In the past month/week how often have you felt that you were unable to control important things in

your life?", "In the past month/week, how often have you felt confident about your ability to handle your personal problems?", "In the past month/week, how often have you felt that things were going your way?", and "In the past month/week, how often have you felt difficulties were piling up so high that you could not overcome them?"). The scale overall has an acceptable reliability ($\alpha = .61$, $M = 3.99$, $SD = .73$).

Social activity. Participants' levels of social activity, both within and outside of the RCC was measured using Jang, Park, Dominguez, and Molinari's (2014) social engagement scale. Participants answered four questions, "How often do you attend social activities in the RCC (such as meetings, recreational programs, and so on)", "How often do you socialize with other residents in the RCC?" How often do you attend social activities outside of the RCC?", How often do you socialize with people outside of the facility?", on a 4-point scale, with 1 being *never* to 4 being *very often*. The scale overall had an acceptable reliability ($\alpha = .77$, $M = 2.71$, $SD = .71$).

CHAPTER FOUR

RESULTS

Data Analysis Plan

All three hypotheses in this study specified an intervening variable model (Hayes, 2009), predicting that the virtual reality intervention (X) would influence the five outcomes outlined above (Y) through the mediating variable, communal orientation (M). Generally, mediation uses three variables (an outcome, predictor, and a mediator) and is best used with longitudinal data (Baron & Kenny, 1986). Traditionally, Baron and Kenny (1986) advise considering three criteria when deciding if a variable should function as a mediator: 1) Do the variations in the levels of the independent variable significantly account for the variations in the hypothesized mediator (*a* path)? 2) Do variations in the mediator account for variations in the outcome variable (*b* path)? and 3) Is a previously significant relationship between the independent variable and the dependent variable no longer significant (*c* path)? They advise that there is only mediation if there is a *total effect* of X*,* meaning the *c* path between X and Y is significant. There are increasingly mixed opinions on whether it is essential for a total effect, however, and many have started to argue that what may be equally important in mediation is the *indirect effect,* or the *a* and *b* paths (Fritz & MacKinnon, 2007; Hayes, 2009; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Zhao, Lynch, & Chen, 2010). Hayes (2009) explicitly challenges the traditional Baron and Kenny (1986) causal steps to testing the intervening variable effect, stating that not only does this method often fail to detect the effect of the intervening variable because it is relying on path analysis without M, it is also illogical to not include "the very thing it is attempting to test – the intervening effect" (p. 410).

For these reasons, the indirect, direct, and total effects will be evaluated to understand whether the intervening variable, communal orientation, mediates the relationship between the intervention and the five outcomes. Modern approaches to inference of the indirect effects have generally fallen into two camps: bootstrapping, (Bollen & Stine, 1990; Shrout & Bolger, 2002) or the Monte Carlo Method for Assessing Mediation (MCMAM; MacKinnon, Lockwood, & Williams, 2004). The MCMAM uses simulated estimates for the *a* and *b* paths and their standard errors to generate a distribution of *ab* values. From this simulated distribution, confidence intervals and *p* values are then generated. Although a highly useful approach, Selig and Preacher (2008) advise that it is best used when data are not available to the researcher. Because the data are available, the second method for obtaining the indirect effects of a mediation model, bootstrapping, will be used. Bootstrapping is a non-parametric method which resamples with replacement many times. From each sample, the indirect effect is calculated, empirically generating a distribution. From that distribution, a confidence interval can then be established, allowing the researcher to determine if it contains zero. If the CI contains zero, the researcher cannot reject the null and mediation cannot be said to have occurred. If the CI does not contain zero, however, the researcher can confidently report that the indirect effect is significantly different from zero (Hayes, 2009).

Another important consideration in this study is the clustered nature of the data. In general, individual observations are assumed to be independent from one another and because of this, traditional analyses are not meant to account for clustered data (Kenny, 1996; Krull & MacKinnon, 2001). However, not taking into account the clustering of the data can lead to correlated errors among individuals within a group, which violates the independent observations assumption of ordinary least squares (OLS) estimation. This can then lead to biased standard error estimates, overly large test statistics, and inflated Type I

errors rates (Krull & MacKinnon, 2001). Because participants in this study were clustered into two groups, statistical analyses taking that nonindependence into account was essential. For this reason, multilevel modeling (MLM) was used to account for the variance both at the individual level and the group level (Campbell & Kashy, 2002; Kenny & Cook, 1999). One reason multilevel modeling is preferred for this type of data is because it allows for simultaneous estimation of between- and within-person effects and their interactions, by modelling the within-group homogeneity of errors (Krull & MacKinnon, 2001; Reis & Gable, 2000). This is done is by using maximum-likelihood estimation techniques instead of OLS. MLM also corrects for the standard error associated with the estimated cluster-level effect, which results in a more accurate test of significance. In this study, level one was defined as the individuals' repeated measures across the four weeks nested within the individual (level 2), which was then nested within the individual's assigned group (virtual reality or television; level 3). Because the initial (X_j) variable was dichotomous, meaning it could take on a unique value for each of the two groups for all three hypotheses, and the mediator (M_{ij}) and outcome (Y_{ij}) variables were individual characteristics or behaviors, the model was labeled a 2-1-1, or a *lower level mediation* (Bauer, Preacher, & Gil, 2006). Figure 1 displays a recreation of this mediational structure first presented by Krull and MacKinnon (2001).

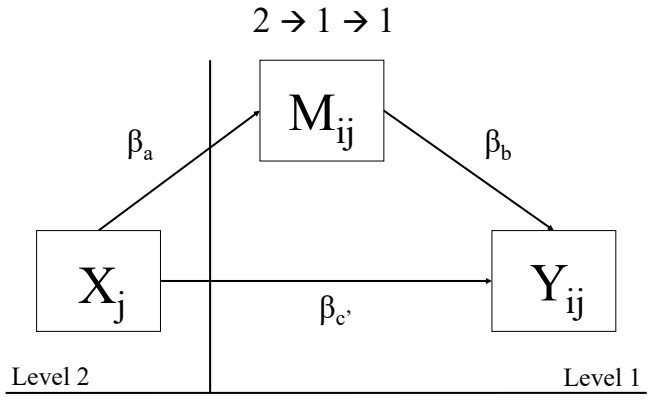

Figure 2. *Recreation of Krull and MacKinnon's (2001) mediational 2-1-1 structure*

Multilevel mediation analysis can become complicated because variables can be conceptualized at both the individual and group level, depending on if the research uses individual, repeated measures or the mean for each group. In single-level mediation, path analyses can be conducted by calculating three regression equations testing the *a*, *b*, and *c* paths. However, the generation of multilevel estimates of the mediated effect must be calculated utilizing multilevel coefficients and standard error estimates. Comparisons of these equations can be found below:

Equation 1	Equation 2	Equation 3
Single-Level:	Single-Level:	Single-Level:
$Yij = \beta_0 + \beta_c X_j + r_{ij}$	$Y_{ij} = \beta_0 + \beta_c X_j + \beta_b M_{ij} + r_{ij}$	$M_{ij} = \beta_0 + \beta_a X_j + r_{ij}$
Multilevel:	Multilevel:	Multilevel:
Level 1: $Y_{ij} = \beta_{0j} + r_{ij}$	Level 1: $Y_{ij} = \beta_{0j} + \beta_b M_{ij} + r_{ij}$	Level 1: $M_{ij} = \beta_{0j} + r_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_c X_j + u_{0j}$	Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{c'} X_j + u_{0j}$	Level 2: $\beta_{0j} = \gamma_{00} + \gamma_a X_j + u_{0j}$

In a 2-1-1 multilevel model, the initial variable is at the group level and is included as a predictor of the group intercept. This inclusion of the group level initial variable in the second equation creates the multilevel estimate of the *c'* path. The intercept is treated as a random coefficient, giving each group a unique intercept value. The overall intercept term, specified by γ_{00}, and group level error term, u_{0j}, is then predicted in the group level equation.

This second error term allows the multilevel model to accommodate the correlated error structure that clustered data presents (Krull & MacKinnon, 2001).

With these considerations in mind, while also considering the small sample size (N = 47), separate multilevel mediation models were run for each outcome using the "lme4" package (Bates, Maechler, Bolker, & Walker, 2015) in R version 3.5.3 (2019-03-11 – "Great Truth"). For all three hypotheses, a multilevel mediation model with repeated measures at level 1 (e.g., vitality), the individual specified as the grouping variable, and the intervention specified as the predictor variable, were estimated to predict individuals' quality communication, social engagement, vitality, communal orientation, loneliness, depression, and stress.

Data Preparation

Items were first recoded and frequencies and descriptives were run to assess the accuracy of the data collected and the effects of any outliers identified. Dummy coded variables were created (0 and 1) to distinguish between the virtual reality and television conditions (see also Kashy & Donnellan, 2008). All scales used in the study were subjected to confirmatory factor analysis with oblique rotation to ascertain the best initial structures of the measures for each component of the model. All factor analyses entailed the same procedures. Extraction of components was guided by eigenvalues > 1. Items were determined to be loaded if the primary loading was > .50 with no secondary loading > .30, and reliability of the loaded items was acceptable (i.e., > .70).

For chronic emotional capital, the factor analysis indicated a highly satisfactory Kaiser-Meyer-Olkin coefficient (KMO = .90) and one component was produced with eigenvalues > 1.0. The resulting one-component solution accounted for 76% of the common variance. When examining the revised UCLA loneliness scale, the factor analysis indicated a

Kaiser-Meyer-Olkin coefficient just below the .70 threshold (KMO = .65), however, all items were moderately to highly correlated with one another. The resulting one-component solution accounted for 70% of the common variance. A factor analysis of Ryan and Fredrick's (1997) vitality scale indicated a highly satisfactory Kaiser-Meyer-Olkin coefficient (KMO = .88) and one component was produced with eigenvalues > 1.0. The resulting one-component solution accounted for 62% of the common variance. The 15-item Geriatric Depression scale produced a satisfactory Kaiser-Meyer-Olkin coefficient (KMO = .74). Six components were produced with eigenvalues > 1.0, but the scree plot revealed leveling between the first and second components. The resulting one-component solution accounted for 31.52% of the common variance. When analyzing the 11-item communal orientation scale, the factor analysis indicated a highly satisfactory Kaiser-Meyer-Olkin coefficient (KMO = .83). One component was produced with eigenvalues > 1.0. Finally, factor analysis of Duck et al.'s (1991) quality communication scale indicated a highly satisfactory Kaiser-Meyer-Olkin coefficient (KMO = .85). Two components were produced with eigenvalues > 1.0. The resulting two-component solution accounted for 74% of the common variance. The first component, labeled *quality communication*, loaded 6 items: 'listening', 'depth', difficulty', 'understanding', 'conflict', and 'support'. The second component, labeled *openness*, loaded one item: 'openness'.

Reliabilities for the variables of interest were checked and then composite variables were formed. Additionally, two outcome variables, loneliness and depression, had skew values above or below +1.0 and -1.0. To address this, each of the variables were transformed using a natural log transformation. The natural log transformation successfully corrected normality issues for depression. Although the natural log improved the skew score for loneliness (1.85 to 1.39), the score still remained over the 1.0 threshold. A square root

transformation was then used; however, this only exacerbated the skew score (1.39 to 1.58). Finally, a reciprocal transformation was used, which did improve the skew, however the skew score remained over the +/-1.0 threshold (-1.15).

The data were then screened for missing values and outliers. Because this was such a difficult sample to maintain over the course of the four weeks, there was a significant amount of missing data. To manage this, multiple imputation by chained equations was used. Multiple imputation uses the Expectation Maximization (EM) algorithm to obtain maximum likelihood (ML) estimates in incomplete data (Rubin, 1987, 1996; van Buuren & Groothuis-Oudshoorn, 2011) and has been shown to reduce bias (Peugh & Enders, 2004). Multiple imputation creates a small number (*m*) of completed matrices in which missing values are replaced with plausible, predicted values (van Buuren, Boshuizen, & Knook, 1999). Past research generally uses between 3 to 5 imputations, which is determined by the amount of missing information in the data. Once these imputations are created, they are then compared to one another to determine the variability between them. High variability indicates uncertainty about the predicted values. In general, if the complete data shows valid inferences in the place of missingness and if the imputation procedure is executed with respect to the non-response mechanism, then multiple imputation will produce valid values (van Buuren et al., 1991).

To account for the longitudinal nature of the study with fixed occasions as well as the clustered nature of the sample, the data were restructured from a long to a wide format before the imputation. It is common to structure longitudinal data in a long format, which has multiple records for each individual, whereas in the wide format, every measure that varies in time occurs in a set of columns. When the data are in a long format, some of the variables that do not vary in time are identical, for instance age, whereas other variables vary

across the records. Multiple imputation has been shown to be more convenient in the wide format because the columns are ordered in time. To conduct the multiple imputation, the R software package Multivariate Imputation by Chained Equations or MICE (van Buuren & Groothuis-Oudshoorn, 2011) was used. MICE can be used to inspect the missingness patterns in the data, impute missing data, diagnose the quality of the imputation, analyze completed datasets, and pool the results of the repeated analyses, among other things.

First, all data except the quality communication measure were classified as missing at random (MAR), which is the desirable scenario in the case of missing data. This was done by checking the data for their percentage of missingness. Because the quality communication measure was determined to be not missing at random (NMAR) and was missing over 47% of its values, it was determined that it was unwise to impute those missing values (van Buuren & Groothuis-Oudshoorn, 2011). Upon further exploration, it was discovered that much of the missing data was due to the way in which the question was worded. Participants were asked to reflect on the communication they engaged in with members of their group over the last week, however many participants indicated on their surveys that they had not interacted with any of their group members since their last survey. Therefore, quality communication was not included in hypothesis testing. Missingness percentages for the rest of the data are reported for each variable in Table 1. Using the MICE package, four parameters were specified. First, five imputed datasets were created, which is MICE's default value. A scalar specifying the number of iterations was set to 50 and an integer, called a seed, was specified to *seed* = 5, which offsets the random number generator, allowing for the data to be replicated. Finally, predictive mean matching (PMM) was specified as the imputation method.

PMM produces imputed values that are much more like real values, meaning if the original variable is skewed, the imputed values will also be skewed. It does this by borrowing values from individuals with real data (Little, 1988; Rubin, 1986). This is accomplished by utilizing cases with no missing data and using a linear regression to estimate the variable containing missingness with a variable with no missingness. The linear regression does not actually generate the imputed values but rather serves to construct a metric for matching cases with missing data to similar cases with data present. PMM draws from the posterior predictive distribution of *b,* producing a new set of coefficients, *b**. This produces sufficient variability in the imputed values and is common in multiple imputation methods. Using *b**, predicted values are then generated for the variable with missingness for both cases with data missing and those with data present. For each missing case, a set of cases with an observed case is identified and a set of cases with values close to the observed cases are predicted for the case with missingness. From those close cases, a value is randomly chosen and assigned its observed value to substitute for the missing value.

Once the data were imputed, the datasets were inspected. The distributions from the original dataset and the new imputed dataset were then compared by creating scatter plots (Figure 3-10). Each scatter plot used "vitality" as a comparison variable along with the variable being examined. The scatter plots showed that the shape of the imputed points matched the shape of the observed points, indicating that the imputed values are indeed "plausible". A density plot was also created. The density of the imputed data compared to the density of the observed data can be seen in Figure 10. Confirming previous assumptions, the distributions appear to be similar. Finally, a strip plot was created to inspect the distributions of the variables as individual points (Figure 11). Pooling was then used to bypass the need to

choose one of the imputed datasets and instead fit a model to each of the imputed datasets and pool the results together.

In rescreening the data for outliers to check assumptions, three tests were run: the Mahalanobis, or the number of standard deviations a score is from the from the mean of the distribution (Filzmoser, 2004), a leverage test, which examines each individual's influence on the slope, and Cook's distance, commonly used in regression to find influential outliers. Each of these tests were run with the final models to analyze each predictor and outcome and outliers were discovered in the variables *loneliness*, *communal orientation*, *stress*, and *social activity*. Those data were then winsorized to reduce any negative effect the outliers identified may have on the data. This was done by adding the third quartile to 1.5*the interquartile range of the data for each variable.

Preliminary Analyses

The means, standard deviations, and correlations with confidence intervals for the variables of interest for both the intervention and control groups are presented in Table 3. On average, participants entered the study with fairly high levels of vitality (M = 5.77, range = 1-7), communal orientation (M = 4.54, range = 1-7), and social activity (M = 2.79, range = 1-4) at their baseline. Participants also had a moderate amount of stress at their baseline (M = 3.97, range = 1-5). To get an overall understanding of depression within the sample, each individual's scores were averaged across all four weeks and counted. As stated previously, an individual was determined to be depressed if they scored a four or more. In the sample, N = 23 scored a four or more, indicating that 49% of the sample were experiencing symptoms of depression. Independent t tests were run to ensure that there was no significant difference between groups at the baseline (see Table 4). There were no significant differences between the virtual reality intervention and the television group on any of the measured variables.

A linear mixed model, with Time and the intervention entered as predictors and chronic emotional capital as the outcome, was then run to understand if the use of VR encouraged participants to engage in other relational maintenance actions and behaviors with other residents (e.g., complimenting one another, smiling at one another, and making each other laugh). Unfortunately, the overall model was not significant, $F(7, 180) = .42$, $R^2 = .02$, $p = .88$, and did not reveal a significant relationship between the intervention and increased relational maintenance behaviors, $b = .08$, $t(180) = .20$, $p = .84$, or increased relational maintenance behaviors at Time 4, $b = -.21$, $t(180) = -.29$, $p = .77$. This may again be because of how the question was worded, which asked participants to reflect on how much other residents in their group have done these actions and behaviors in the past week, as opposed to how much they themselves had done these actions and behaviors. This indicated that being in the VR condition did not make residents perceive more relational maintenance from the other members of their group. This finding makes sense when one considers that the majority of individuals in either group reported they did not see their group members in between sessions, and therefore the way relational maintenance was measured in this instance was not appropriate for this particular sample. The fact that this manipulation check failed to detect increased relational maintenance actions and behaviors amongst individuals in the experimental group compared to the control group may also indicate that relational maintenance only occurs with close friends within an RCC, even when residents are participating in a group activity together, and that a different finding may have emerged in a smaller community where residents all see one another every day (this community contained over 400 residents). It is likely that wording the question differently to ask about the individual's personal relational maintenance actions and behaviors could provide interesting insights into how they interact with their community as a whole. But it does not change the

fact that the residents in the VR condition still experienced the VR, which is a maintenance activity, and the comparison group did not.

Hypothesis Testing

As mentioned previously, the goal of multilevel mediation is to assess the within-person and between-person relationships between X, M, and Y, while accounting for the clustering that takes place when there are two distinct groups with overtime nature of the data. First, to account for the longitudinal nature of the data and to test the need for a multilevel model, unconditional, intercept-only models were created for all outcomes to test for variation across groups on each outcome (Baayen et al., 2008). In mixed-effects models, it is important to account for additional variance components beyond the traditional linear regression model. Broadly, this means associating different types of variance to different groupings, with the remaining unexplained variance included in the model as the residual. Conceptually, the mixed-effects formula the "lme4" package utilizes is split into four parts: the outcome, the fixed effects (or the variables used to predict the outcome by representing each individual's average trajectory), the random effects (or the deviations from the average trajectory for each individual), and finally the identification number of each individual that was measured repeatedly. Because this was a longitudinal study, "individual" was identified as the nesting variable and random effect. The inclusion of random effects helps the linear mixed models take into account the dependency due to repeated measurements:

```
outcome ~ fixed effects + (random effects | individual)
```

Prior to model fitting of a longitudinal model, one must be subtracted from the Time variable so that Time starts at zero and the intercept is specified as the mean of the outcome

for the first timepoint. The random intercept and the traditional fixed intercept are included by specifying a one inside the parentheses, which means that each individual will have a unique starting point that will deviate from the average starting point. Traditionally, mediation is done under the assumption that the causal effects are fixed, not random. By conducting analyses this way, the strength of the effects will be the same for both groups (Level 2). However, in lower level mediation the causal effects can also be random, since the predictors reside at Level 1 (Bauer et al., 2006). This means that the mediator may be a random effect on the outcome. By allowing the causal effects to be random, the researcher can then test whether there is heterogeneity in the strength of the indirect, direct, and total effects and the preciseness with which they can predict the population effects. For these reasons, the focus of these analyses will be to estimate and test the indirect, direct, and total effects with random causal variables, instead of fixed as is traditionally done.

To conduct these analyses, the function "indirect.mlm" (Page-Gould & Sharples, 2016)[1] was used within the function "boot()" (Canty & Ripley, 2019) to conduct the multilevel mediation with bootstrapping. Using the combination of this software as opposed to traditional statistical packages, such as SPSS MIXED, is attractive because it allows the researcher to save random slopes. Traditionally, fixed slopes are used to calculate the indirect effect, however, this method introduces bias, depending on how much the *a* and *b* slopes covary (Bauer, Preacher, & Gil, 2006; Kenny, Korchmaros, & Bolger, 2003). Therefore, the between-person, unbiased indirect effects were calculated by finding the product of *a* and *b*, indirect effect = a*b, and the unbiased, between-person total effect was calculated by adding

[1] Although currently unpublished, more information about this package can be found in the presentation notes titled, "Accurate Indirect Effects in Multilevel Mediation Analysis with Repeated Measures Data", originally presented at the Advances in Repeated Measures Mediation Analysis Symposium at the annual meeting of the Society for Personality and

the indirect effect to c' (total effect = indirect effect + *c*'). The within-person effects were then calculated by multiplying the indirect effect for each person by the mean, indirect effect = mean(a_i*b_i) and the unbiased, within-person total effect was calculated by multiplying the indirect effect of each individual plus the *c*' by the mean, unbiased total effect = mean*(indirect effect$_i$ + c'). "Indirect.mlm" also grand mean centers the mediator. Centering mediating variables impacts how intercepts are interpreted, the variance of random intercepts, and random slopes covariance (Bryk & Raudenbush, 1992). Centering at the grand mean (as opposed to within the cluster), is appropriate for analyses exploring the effect of the predictor variable on the mediator at the individual level, as long as the predictor represents an individual characteristic (Tofighi & Thoemmes, 2014). When the mediator is centered in a 2-1-1- analysis, the within-cluster indirect effect, through the within-cluster part of the mediator, and the unique between-cluster indirect effect, through the cluster means are decomposed (Tofighi & Thoemmes, 2014). This unique between-cluster indirect effect creates a contextual indirect effect beyond the within-cluster effect (Pituch & Satepleton, 2012; Tofighi & Thoemmes, 2014).

When run, this function creates a mediated multilevel model for each outcome, using the resampled data from the bootstrapping (see Figure 12-15 for a histogram and QQ plot for each of the bootstrapped distributions). All five models were estimated with Time and the intervention specified as random effects and used maximum likelihood (ML) estimation. All models also specified the covariates: *how close by family lived* and *how often they spoke with their families*, *how long the individual lived at the RCC*, *how many people they knew in their group and how many were strangers*, *their marital status,* and *if they were providing care for a romantic partner*. All models were bootstrapped 5000 times (see also Hayes, 2009). All

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Social Psychology. A citation for this presentation will be provided in the references list

findings reported below are unbiased (for the biased statistics, see Tables 3-7). The analysis was done in R using the following script:

```
boot(data = data.set, R = 1000, strata = ID, statistic
= indirect.mlm, y = "outcome", x = "predictor", mediator =
"mediator, covariates = "all covariates indicated for
study", group.id = "ID", between.m = F, uncertered.x = F)
```
[2]

Hypothesis 1a: Social Activity

H1a predicted that individuals randomly assigned to the experimental group would experience greater levels of communal orientation, and in turn, be more socially engaged than the comparison group. A multilevel mediation was run with the intervention as the predictor, communal orientation as the mediator or intervening variable, and social activity as the outcome, as well as the control variables stated above as covariates. Indirect effects were tested first. The total within-person indirect effect, $mean(a_i*b_i)$, was not significant (b = .004, p > .05, 95% bias corrected CI: -0.051, 0.037), indicating that there was no significant change in social activity over the four weeks within individuals in the virtual reality intervention. This was also true for the total between-subjects effect, (b = -.06, p > .05, 95% bias corrected CI: -0.087, 0.006), showing there was also no change in social activity between groups over the study, demonstrating that the effect of the intervention on residents'

(Sharples & Gould, 2016).

[2] With the *data* argument referring to the data frame containing all of the study variables, the *R* argument specifying the number of bootstrap resamples desired, *strata* identifying the grouping variable (i.e., subject id), *y* identifying the outcome variable, *x* identifying the predictor variable, *mediator* identifying the name of the mediating variable (it is recommended that this should always be uncentered; Page-Gould & Sharples, 2016) *group.id* matching the variable that identifies grouping variable, *covariates* identifying the variable names of the covariates, *uncentered.x* indicating whether the predictor is uncentered (the default for this argument is TRUE, and the function group-mean centers the predictor on each iteration, however, since the *x* references a dummy coded categorical variable, it is advised to set this value to FALSE so the function will leave the predictor coded as it is in

social activity via communal orientation did not significantly increase how socially active they were (see Table 3 and Figures 15-16).

Next, the direct effects were tested. The within-subjects effect of the virtual reality intervention on communal orientation (*a* path) had a significant, negative relationship, (b = -.216, p < .05, 95% bias corrected CI: -0.354, -0.063), implying that being in the virtual reality intervention was significantly associated with less communal orientation. The within-subjects effect of communal orientation on social activity (*b* path) did not reveal a significant relationship, (b = .008, p > .05, 95% bias corrected CI: -0.086, 0.118), nor did the between-subjects effect of communal orientation on social activity, (b = .107, p > .05, 95% bias corrected CI: -0.016, 0.188). These findings indicate that communal orientation did not have a significant effect on social activity, either within the individual or between the two groups. The relationship between the virtual reality intervention and social activity (*c'* path) was significant, however, (b = -.221, p < .05, 95% bias corrected CI: -0.354, -0.063), showing that there was a direct and significant association between the virtual reality intervention and residents' social activity. The total effect, $mean(indirect\ effect_i + c'_i)$, confirmed this assertion by revealing a significant, negative relationship between the virtual reality intervention and social activity, (b = -.216, p < .05, 95% bias corrected CI: -0.360, -.067). Being in the virtual reality condition was significantly associated with less social activity than the comparison group. Therefore, H1 was not supported.

Supplemental analyses using linear mixed models were run to understand what may have been more successful predictors of social interaction and two variables emerged. First, there was a positive association between the number of strangers in their group for the study and how socially engaged they were, $b = .23$, $t(38) = 2.39$, $p = .02$, indicating that it is

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the dataset's data frame; *between.m* indicates the desire to disentangle the within-group and

possible that more socially engaged residents are more likely to be spending time outside of the RCC and less likely socializing with other residents. Second, the more staff members the individual considered close friends, the more socially engaged they were, $b = .08$, $t(38) = 3.09$, $p < .01$. This may have interesting implications for the role that staff can play in the creation of virtual reality centered recreational activities and encouraging increased levels of social engagement.

Hypothesis 1b: Vitality

H1b predicted that individuals randomly assigned to the experimental group would experience greater levels of communal orientation, and in turn, experience higher levels of subjective vitality than the comparison group. Indirect effects were again tested first. The total within-person indirect effect was not significant, (b = -.08, p > .05, 95% bias corrected CI: -0.137, 0.103), indicating that there was no indirect effect of the virtual reality intervention across the four weeks of the study on vitality within individuals. However, the total between-subjects effect showed that there was a significant, negative relationship between the intervention and vitality, (b = -.317, p < .05, 95% bias corrected CI: -0.452, -0.124), showing that with communal orientation as a mediator, individuals in the virtual reality intervention experienced less vitality than individuals in the television group. This finding seems unintuitive; however, the results of the direct effects tests begin to illustrate a clearer picture.

The within-subjects effect of the virtual reality intervention on communal orientation (*a* path) again revealed a significant, negative association, (b = -.29, p < .05, 95% bias corrected CI: -0.022, -0.497), likely driving the negative association found in the indirect effects tests. The within-subjects effect of communal orientation on vitality (*b* path) did not

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between-group effects for the mediator.

reveal a significant association, (b = .19, p > .05, 95% bias corrected CI: -0.074, 0.334), showing that there was not a significant effect of communal orientation on vitality within individuals across the study. However, the between-subjects effect was significant, (b = .79, p < .05, 95% bias corrected CI: 0.491, 0.862), showing that there was a difference between groups such that residents in the virtual reality group who had higher levels of communal orientation, also had higher levels of vitality. Even more interestingly, there was a significant positive relationship between the virtual reality intervention and vitality (*c'* path), b = .31, p < .05, 95% bias corrected CI: 0.022, 0.506), showing that the virtual reality intervention did exert a positive effect on levels of vitality, with communal orientation as a mediator, however just not in the way previously hypothesized. To reiterate, the *c'* path is the direct path between X (the virtual reality intervention) and Y (vitality in this instance) when the mediator is in the model. This finding further supports the notion that communal orientation may be playing a different role in these associations than originally thought (see Table 4 and Figures 17-18). The total indirect effect, or the *c* path, was not significant, (b = .22, p >.05, 95% bias corrected CI: -0.021, -.497). Therefore, H1b was partially supported.

Hypothesis 1c, d, & e: Loneliness, Depression, & Stress

Finally, H1c, d, and e predicted that individuals randomly assigned to the experimental group would experience greater levels of communal orientation, and in turn, lower levels of loneliness, depression, and stress than the comparison group. Models were conducted separately for each outcome, with loneliness tested first. Tests of indirect effects showed that the total within-person indirect effect was not significant (b = .004, p > .05, 95% bias corrected CI: -0.060, 0.051), meaning that individuals in the virtual reality group did not significantly experience changes in their levels of loneliness across the four weeks of the intervention via communal orientation. The total between-subjects effect was also

nonsignificant, (b = -.06, p > .05, 95% bias corrected CI: -0.116, 0.016), showing that there was also no difference between groups on levels of loneliness when communal orientation intervened between the group and loneliness.

Next, the direct effects were tested. The within-subjects effect of the virtual reality intervention on communal orientation (*a* path) again had a significant, negative relationship, (b = -.41, p < .05, 95% bias corrected CI: -0.618, -0.194). The within-subjects effect of communal orientation on loneliness (*b* path) did not reveal a significant relationship (b = -.01, p > .05, 95% bias corrected CI: -0.091, 0.113), indicating that there was not a significant change in individuals' levels of loneliness across the four weeks as a function of their communal orientation. The between-subjects effect was also not significant (b = .11, p > .05, 95% bias corrected CI: -0.018, 0.192), showing that there was also no significant difference in loneliness between the groups when communal orientation was taken into account. The association between the virtual reality intervention and loneliness (*c'* path) was significant (b = -.26, p < .05, 95% bias corrected CI: -0.562, -0.036), suggesting being in the virtual reality intervention lowered residents' levels of perceived loneliness overall. Corresponding with the previous finding, the total indirect effect was also significant, (b = -.25, p < .05, 95% bias corrected CI: -0.558, -.038), confirming that individuals in the virtual reality intervention were less lonely than individuals in the television group (See Table 5 and Figures 19-20). Therefore, H1c was partially supported.

Depression was then placed in the model and analyzed as an outcome. Tests of indirect effects did not show a significant within-person indirect effect (b = .02, p > .05, 95% bias corrected CI: -0.008, 0.056), showing that individuals in the virtual reality intervention did not experience lower levels of depression over time by being in the four-week intervention. There was also no between-subjects effect (b = .004, p > .05, 95% bias

corrected CI: -0.017, 0.030), indicating that there was no difference between depression levels overall between the two groups.

The direct effects again illustrated the negative within-subjects effect of the virtual reality intervention on communal orientation (*a* path; b = -.49, p < .05, 95% bias corrected CI: -0.619, -0.171). The within-subjects effect of communal orientation on depression (*b* path) did not reveal a significant relationship (b = -.06, p > .05, 95% bias corrected CI: -0.115, 0.014), indicating that there was no effect of communal orientation on depression levels for individuals across time. There was also no between-subjects effect (b = -.01, p > .05, 95% bias corrected CI: -0.067, 0.040), meaning there was no significant difference between the two groups in levels of depression when communal orientation was taken into account. The association between the virtual reality intervention and depression for both the *c'* (b = .10, p < .05, 95% bias corrected CI: 0.042, 0.171) and the total effect, *c* (b = .23, p < .05, 95% bias corrected CI: 0.054, .203), showed significant, positive associations, suggesting that (with and without communal orientation) the virtual reality intervention may have been associated with greater symptoms of depression. Therefore, H1d was not supported.

Finally, stress was entered into the model as the outcome. Tests of indirect effects did not show a significant within-person indirect effect (b = -.01, p > .05, 95% bias corrected CI: -0.076, 0.036), meaning individuals in the virtual reality intervention did not experience less stress as a result of the virtual reality intervention over the four weeks, or a between-subjects effect (b = -.03, p > .05, 95% bias corrected CI: -0.083, 0.007), meaning that there were no significant differences in stress between groups with communal orientation as the mediating variable.

The direct effects again illustrated the negative within-subjects effect of the virtual reality intervention on communal orientation (*a* path; b = -.41, p < .05, 95% bias corrected CI: -0.620, -0.193). The within-subjects effect of communal orientation on stress (*b* path) did not reveal a significant relationship (b = .03, p > .05, 95% bias corrected CI: -0.072, 0.166), indicating that individuals with higher communal orientation did not experience lower levels of stress. The between-subjects effect was also not significant (b = .08, p > .05, 95% bias corrected CI: -0.018, 0.018), showing that there was no difference in stress levels between groups regardless of the level of communal orientation. The relationship between the virtual reality intervention and stress (*c'* path) also did not yield a significant result (b = -.13, p > .05, 95% bias corrected CI: -0.256, 0.052), showing that when accounting for communal orientation, there still was not a significant association between the virtual reality intervention and stress. Finally, the total effect was also not significant, (b = -.14, p > .05, 95% bias corrected CI: -.283, .048), showing that even without communal orientation in the model, there was no effect of the virtual reality intervention or feelings of communal orientation on perceived stress. Therefore, H1e was not supported.

Interestingly, supplemental analyses using linear mixed models revealed that there was a significant, positive main effect for technology experience, $b = .20$, $t(44) = 4.24$, $p < .001$, indicating that when experience with technology was perceived as greater, stress was also greater for residents.

Communal Orientation

To understand why the communal orientation coefficients in the models negative, further exploration was done through plotting the interactions. The plot showed a difference between the two groups at week 1, however, a *t-test* indicated there was no significant

difference between the virtual reality group and the television group, $t(44) = 1.33$, $p = .19$, 95% CI [-.27, 1.33].

CHAPTER FIVE

DISCUSSION

The primary goal of this study was to investigate whether virtual reality could serve as a relationship maintenance tool for residents in residential care communities. Using the theory of resilience and relational load (TRRL; Afifi et al., 2016), the present study hypothesized that residents who participated in the experimental group by using virtual reality once a week for four weeks would experience higher levels of communal orientation, or a sense of unity with one another. Communal orientation was predicted to then, in turn, lead to increased social activity, higher quality communication with other residents, and subjective vitality. Higher communal orientation was also hypothesized to decrease feelings of loneliness, stress, and symptoms of depression. The analyses yielded mixed results. Unlike what was predicted, communal orientation was not a significant mediator in any of the models. Most nonintuitively, there was a negative association between the virtual reality intervention and communal orientation in all five models. This may imply a few different conclusions. First, it could be that, for this population, the virtual reality intervention did not act as a relational maintenance activity. If this were the case, it would be logical that the activity would not increase levels of communal orientation and it would be important to further investigate how the activity was viewed by the residents. This will be discussed further below. It could also be that communal orientation was actually a moderating variable, as opposed to a mediating variable. Often in mediation analyses, intervening variables reveal themselves as moderating variables when the *c'* path is strengthened with the addition of the third variable, which was true for vitality. It will be important for future research to establish that the virtual reality intervention is in fact a relational maintenance activity and potentially test communal orientation as a moderating variable.

The full mediation analyses revealed that participants in the virtual reality intervention did experience lower levels of loneliness and higher levels of subjective vitality overall. In the vitality model, higher levels of communal orientation also predicted higher levels of vitality. Unfortunately, there was also evidence that the virtual reality intervention was associated with lowered levels of social activity and increased levels of depressive symptoms. There was no evidence that the intervention lowered levels of stress. These findings are difficult to understand on their own. However, digging into the theoretical and methodological reasons clarifies what may be co-occurring alongside the intervention. The following discussion will elaborate on the potential reasons for these findings and the implications they may have on the TRRL.

Communal Orientation and Relational Maintenance Between Residents in an RCC

According to the TRRL (Afifi et al., 2016) relational partners who engage in more relational maintenance behaviors are more likely to feel a sense of communal orientation toward one another. This should then promote investment in the relationship, which builds emotional reserves (Driver & Gottman, 1999; Gottman, Driver, & Tabares, 2002). When relational partners have established these relational practices, generally as a process over time, they should then be better equipped to manage stressful events in their lives (Fredrickson, 2001). This theoretical thinking has been stable in past research examining couples and families (Afifi et al., 2016; Afifi et al., 2018; Afifi, Zamanzadeh, Harrison, & Callejas, 2018). Couples and families who put in the relational work are consistently less stressed and more likely to experience resilience. When applying these concepts to individuals whose relationships exist solely because of the community they live in, it is only reasonable that these relational processes begin to look different. For instance, the fact that these data indicate that virtual reality as an interventional tool promoting relational

maintenance was negatively related to communal orientation may be a symptom of the type of sample (i.e., residents alongside one another in an RCC) instead of the intervention itself. It would be a worthwhile endeavor to explore an intervention such as this one in romantic (e.g., spouses) or familial relationships (e.g., adult children and their older parents) to gain a deeper understanding of the full impact virtual reality could have in promoting relational maintenance and communal orientation in older adults.

It is also possible that feeling more communally oriented to your community could actually be negative if you are either not receiving the same feelings back or the community is constantly changing. In a qualitative study examining social isolation and loneliness in RCC's, Finlay and Kobayashi (2018) discovered that many individuals seek solitude later in life, likely causing them to be unlikely or unwilling to interact with their fellow residents, much less show relational maintenance. Another contributing factor could be major changes in the community. In our initial survey, we asked participants to indicate if, in the past month, "there had been any major changes in the community regarding the residents (e.g., a large number of new residents moving in or leaving)". Qualitative responses showed that there had been an influx of new residents in the past month and there had also been many deaths in the community or residents who had moved away for more advanced care. In these situations, feeling communally oriented could actually backfire because the very people an individual was depending on to help manage the stress of the aging process are - sometimes without warning - no longer there. CEMSA states that individuals age successfully when they have been able to develop an aging space that allows them to lessen the uncertainties of aging. However, with constant changes within the community, the aging space may have trouble developing.

The TRRL also outlines resilience, as an outcome and a process, positing that when individuals experience communal orientation and relational maintenance, they should experience less stress. When stress naturally occurs, they should also better appraise the stress and communicate in more secure and less threatening ways compared to people who have less communal orientation and less accrued maintenance. This should promote resilience, which should make people feel more alive and vital. Said in another way, individuals who feel as though they are in a supportive and cohesive environment should be less likely to experience distress and more likely to thrive compared to individuals who are in a less supportive and cohesive environment (Missotten, Luyckx, & Seiffge-Krenke, 2013). Afifi et al. (2018) show that even when individuals are managing a chronic illness, they are still able to feel unified against the stress of the illness. Even more importantly, individuals can learn how to implement important relational maintenance and communal orientation actions and behaviors into their relationships. This is an important reminder for this study as well, considering the lack of association between the virtual reality intervention and measured chronic emotional capital. Future research could implement an amalgamation of these interventions, still encouraging residents to interact with one another within the virtual world but also instructing them to actively use prosocial relational maintenance strategies in between sessions outside of the virtual world. This addition to the design may have wide reaching effects on many of the measured outcomes for this study.

Finally, it is possible that the study set-up influenced feelings of communal orientation for the television group. The groups were only separated by a sliding door and before each session started, they could see one another. This promoted feelings of envy for some of the television group members and in one instance one television group member actually tried to join the virtual reality group instead. If participants in the television group

were able to bond over their shared feelings of envy or displeasure that they were not in the virtual reality group, then it could be that their communal orientation was strengthened.

Vitality and Loneliness in an RCC

A positive outcome of the current study is that the virtual reality intervention was associated with higher levels of subjective vitality. This finding is encouraging for a number of reasons. First, qualitative research has confirmed that programs that present novel and rewarding benefits increase feelings of vitality (Saravanakumar, Higgins, Wan Der Riet, & Sibbritt, 2018). As stated previously, residents with functional disabilities are especially vulnerable to experiencing lower levels of subjective vitality. For instance, Contrera et al., (2016) found that residents with hearing impairment were 23% less likely to experience emotional vitality when compared to residents without hearing impairment. Virtual reality has been shown to improve feelings of vitality in older adults (Carrasco, Ortiz-Maqués, & Martínez-Rodríguez, 2019; Lee, Son, Kim, & Yoon, 2015; Shin, Park, & Jang, 2015). This finding adds to previous research by showing that virtual reality can also help improve social outcomes.

The virtual reality intervention was also associated with lower levels of loneliness. Loneliness is prevalent for many older adults living in an RCC and it is well established that loneliness and feelings of social isolation can become major risk factors for both physical and mental illness for older adults (Ong et al., 2016). This risk is even greater for residents with functional decline (e.g., decreased gait speed), who are more likely to experience loneliness and social isolation (Shankar, McMunn, Demakakos, Hamer, & Steptoe, 2017). There was a wide variety of abilities in this sample and the fact that virtual reality was associated with less loneliness overall indicates that this was regardless of functional ability.

Social Activity in an RCC

This study also explored the effect virtual reality could have on residents' level of social activity, both within the RCC and outside of it. The total effect showed that the virtual reality intervention was associated with less social activity. The finding can be explained in a few ways. First, social engagement may be more complex than a four-item scale can capture. Amano, Morrow-Howell, and Park (2019) argue that using measurements like this may be inappropriate because often older adults engage in very different activities but end up with the same score on the scale. They continue that this can be problematic because different social activities can have different effects on cognitive functions (Amano, et al., 2019; Bielak, Gerstory, Anstey, & Luszcz, 2014). It is probable that this rationale can be extended to relational processes, such as relational maintenance and communal orientation, as well. For instance, attending different activities within the RCC may provide varying levels of interaction (e.g., playing bingo versus watching a movie), which likely increases or decreases levels of relational bonding. Different activities may also present different motivations for attendance, such as a religious activity. Amano, Park, and Morrow-Howell (2017) suggest to instead identify clusters or patterns of activities. By doing this, it may disentangle some of the variation in social activity and how it relates to relational processes between residents within the RCC. When measuring social engagement, Amano et al., (2019) identified three patterns that are important to consider: informal, formal, and low social engagement.

If residents of RCC's fall primarily into the formal social engagement or low social engagement categories, they will likely struggle to form deep bonds with fellow residents because their motivation for attendance is likely not social. It is probable that participation in this study was viewed as a formal social engagement (mandatory attendance in the same activity with no flexibility in time, place, or individuals participating). If this was the case, it is possible that there was a certain level of selection bias of people who are more likely to

participate in more formal social activities, but not other social activities within and outside of the RCC. This could explain the supplemental analyses, which showed that the two strongest predictors of social engagement were: 1) the number of strangers in an individual's group (suggesting that the most socially engaged people in the RCC knew fewer people in their groups for the study) and 2) how many staff members they considered close friends. These supplemental analyses also suggest that when designing future research, it is important to work closely with the staff in designing the study, as they often have insights into the community that would otherwise be overlooked.

Depression and Stress

Once the demographic information of the sample was known, the reasons for depressive symptoms being so high (49% of the sample) and that these symptoms were not significantly improved by the intervention became clearer. Seventy-two percent of the sample were women and past research has shown that women, especially those who live alongside others in residential care communities, are more likely to experience depressive symptoms and a perceived lower quality of life than men (Henning-Smith, 2016). Depression and depressive symptoms likely require a much longer and more frequent intervention than once a week for one month. However, this does not mean that virtual reality does not have the potential to improve depressive symptoms.

Both Song and Park (2015) and Lee, Lee, and Song (2015) demonstrated lower signs of depression through different virtual reality interventions. Both of these interventions lasted between six to eight weeks and were integrated into the older adults' schedule five days out of each week. It is probable that, had the intervention been longer, more frequent, and integrated into their formal activities schedule, the results may have been different. There might have been significant effects for time on the outcomes had the study been

conducted over more days and for a longer period of time. Relational maintenance has been shown to be a process that takes time to accrue emotional reserves in times of distress and depression (Afifi et al., 2018).

The TRRL would also predict that relational load may be playing a role here as well. Relational load is the stress and strain placed on a relationship that has not been well maintained (Afifi et al., 2016). Feelings of relational load in a relationship can lead to relationship dissatisfaction, loneliness, anxiety, and depression, among other things. By once again returning to the qualitative data, it was abundantly clear that may of the participants showed signs of "off-topic verbosity," or an "extended series of loosely connected recollections that become increasingly unrelated to the concept of the original stimulus, and thus attenuate sequential coherence" (Yin & Peng, 2016, p. 1). Off-topic verbosity has been shown to be a symptom of lowered inhibition, making the individual unable to distinguish between relevant and irrelevant topics (Dumas & Hartman, 2008). Groups with individuals engaging in persistent off-topic verbosity may have begun to experience relational load from their group, likely eliminating any positive effects of the relational maintenance intervention. Much of this off-topic verbosity also occurred in the post virtual reality focus group discussions, so it is possible that it was the discussions that eliminated the effect of the intervention and not the intervention itself. Future research with this population should consider whether it is important to include off-topic verbosity as a part of cognitive impairment in the screening procedures or develop strategies to manage off-topic verbosity by training research assistants about the strategies to regain control of conversations.

Finally, the fact that the virtual reality intervention did not predict lower levels of stress as a direct effect or via communal orientation was also logical when one considers the finding from the supplemental analyses indicating that technology can be a source of stress

for older adults in and of itself. It is well established that older adults struggle with new technology for a multitude of reasons. Vaportzis, Clausen, and Gow (2017) note that many older adults feel as though there are major barriers to technology use that make everyday use difficult. These barriers may include feelings of inadequacy, usually due to comparison with younger generations. It could be that the residents who have a large amount of experience with technology do so because they are trying to keep up with younger generations. This task may feel impossible while living in an RCC, which typically have limited technological resources (e.g., fast wi-fi, access to up-to-date computers, etc.). It is also well known that increased social media use can lead to upward social comparisons that can intensify depressive symptoms or stress (Appel, Gerlach, & Crusius, 2016; Fox & Moreland, 2015). The exploration of social comparison with older adults online is surprisingly sparse, however. When considering how this knowledge could impact a future study using virtual reality with this population, researchers should not only investigate how and why increased feelings of experience with technology may cause increased levels of stress, but also if this extends to all types of technology or only certain subsets

Limitations and Future Directions

Although this study contributes to the literature in many important ways, it is not without its limitations. A primary limitation is the sample size, which likely created a lack of power. Many of the confidence intervals were right on the boarder of zero, implying that had the sample size been bigger, the findings may have looked different. Even though this sample was small, it is not uncommon for studies with this population and/or technology (Felnhofer et al., 2013, $N = 52$; Hou et al., 2012, $N = 30$; Janssen, Bailenson, et al., 2010, $N = 32$ (study 1), $N = 34$ (study2); Juan & Perez, 2009, $N = 25$; Rooney et al., 2012, N = 29; Salinas, 2005, N = 40 (study 1), N = 20 (study 2); Schlindwein et al., 2013, $N = 33$;

Zanbaka, 2004, N = 23). This limitation is difficult to overcome for aging and technology researchers, however. The research location was chosen primarily for the fact that it had over 400 residents. Having such a large community to work with aided in obtaining an adequate sample. However, the sheer size of this community also meant that many residents who were randomly assigned to be in either the virtual reality condition or the television condition did not see one another in between sessions, making the development of such relational processes as relational maintenance and communal orientation much more difficult. This could be remedied in one of two ways. First, the study could be replicated in a smaller community where residents are more likely to know one another and see one another on a regular basis. This would, however, make the issue of obtaining an adequate sample size even more difficult. The other option may be to lessen the time in between sessions (e.g., instead of once a week for a month, they could participate every day a month for instance). This would guarantee that residents in a large community would see one another every day, eliminating the need for them to see each other outside of the study. It was extremely difficult to get all of the residents together to participate in the study once a week for a month and getting them together every day may be nearly impossible unless it was woven into the daily activities of the RCC. Although the original plan for this study was to work with the community to make the study part of the official activities calendar, in the end, it was not practical for the community because of pre-existing activities the residents had come to rely on. It is important for future research to integrate the VR into the residents' regular activities' schedule. Often the study would conflict with other scheduled activities, causing residents to either have to miss an activity they looked forward to or miss the study that week.

This sample also had a very high socioeconomic status, was mainly Caucasian, well educated, and fairly healthy and it could be that there is a ceiling effect occurring. It is probable that a less affluent and/or educated sample would benefit more from the intervention for a couple of reasons. First, on the initial survey, residents were asked if they had ever used virtual reality before this study. Many of them indicated that they had. A sample with less exposure or access to technology might have a completely different experience. Because of their affluence, many of the residents were also very well-travelled, often commenting throughout the study that they had already been to very exotic places (e.g., Africa and Antarctica). Again, it is probable that a sample with less exposure to travel will find the virtual travel more rewarding. For these reasons, effects detected here may have been stronger had this been a more diverse sample. Future research should work with RCC's in less affluent and more diverse communities to truly understand the potential impact technology like this could have on more typical older adults. Future research should also consider examining the positive effects that virtual reality can have on long distance relationships, such as an older adult and their adult child. Relational processes, such as relational maintenance and communal orientation take relational work and will be more likely to increase in relationships that are already established, creating a larger space for the positive benefits of virtual reality to emerge. Additionally, using this technology as a novel way to keep in touch could encourage families to maintain more frequent and consistent contact with their older loved one.

Additionally, although Rendever has substantially improved their software, there were often synchronization issues with the videos, which pulled attention away from the manipulation and toward fixing the technology. This is likely in large part because of an unstable wi-fi network and future researchers should ensure that they are able to run the

sessions using a strong, stable network. There were also a limited number of videos available to show residents. Because of this, the research team was not able to give residents a choice in what they saw. Although this solved the issue of agreement in which videos the group as a whole might choose, it also introduced unforeseen issues of showing videos to residents that either had no interest in or evoked negative emotions. The most extreme example of this occurred in week three when one video included skydiving and a resident in the television group had recently lost a family member in a skydiving accident. Luckily, this individual was in the television group, thus, the experience did not feel as real as if they had been in the virtual reality group. They were also assured by a research assistant that they could leave the room at any time and not continue the study for that day. They decided to stay and discussed this experience with their group in the focus group. Future research should screen the content of videos with residents prior to each session, if that is an option for them. This is especially important to understand and take seriously as older adults generally experience negative affect with greater intensity than younger adults (Alea, Bluck, & Semegon, 2004). With that in mind, as virtual reality advances and increases in popularity, issues like these will become moot.

The Call for Alternatives to Scaler Measures for Older Adults

The overall purpose of this study was to better understand relational processes within an RCC and how the implementation of new technology, such as virtual reality, could influence those processes. The results revealed that virtual reality does have the ability to lower loneliness and increase subjective vitality but failed to increase social activity or lower depression and stress. Above and beyond sample size and technological limitations, the way these emotional processes are measured surfaced as an extremely important consideration. In all four weeks of the study, residents struggled to provide answers within the confines of the

Likert scales. Many even refused to answer scale items and instead elected to answer the question being asked in their own words by writing responses in the margins of the survey. For instance, in reexamining the original surveys, it becomes immediately apparent that social activity in the RCC was *highly* dependent on the week being asked about. This was an affluent sample, many of whom had family close by. Many of the participants left questions blank, such as, "How often do you socialize with other residents in the facility?" and wrote next to the scale, "I was gone for 5 days last week on a trip with my family".

One of the benefits of longitudinal research is the ability to adjust the study throughout its duration to accommodate the needs of the participants. One example of this can be seen with the Geriatric Depression Scale, which initially only provided "yes" or "no" answer choices. This was so difficult for participants to answer that in the first two weeks, the majority of residents elected to create their own third answer choice of "sometimes". This happened with such frequency in the first two weeks that during week 3 the third option, "sometimes", was officially added to the scale to give residents a little more flexibility in their responses. Even with this addition, however, many residents still provided unsolicited qualitative feedback in the margins of the survey with statements such as, "Answers have been affected by my stroke 6/2/17. My answers would all have been affirmative!". Past research with this population supports this assertion. In a study examining differences in emotional experience between young and old adults, Alea, Bluck and Semegon (2004) found no significant results for scaler measures exploring differences in the intensity and frequency of negative emotions between age groups but differences emerged in autobiographical narratives. They conclude that older adults can more easily express their thoughts and emotions through autobiographical narrative because it allows them to relive the experience. This could be particularly powerful for virtual reality, where the experience

already feels more real than simply talking about it or viewing it on a television screen. Next steps for this study will include examining the qualitative data collected during the four weeks to understand if different findings emerge that were not revealed in the quantitative data.

The debate on whether or not it is appropriate to use Likert scales is not new (Russell & Bobka, 1992). Since their creation by Rensis Likert in 1932, they have become an extremely popular form of measurement for the social sciences. Along with more qualitative options, such as focus groups and interviewing participants, more quantitate alternatives to Likert and Likert-type scales have also been introduced. One such example are phrase completions (Hodge & Gillespie, 2003). Phrase completions consist of an introductory phrase followed by a numeric point continuum that serves as the response key. For instance, "My religious beliefs affect…" with response anchors reading "no aspect of my life" to "absolutely every aspect of my life", with point options in between. Reflecting back on our study measures, the scales that seemed to be the easiest for residents to complete were in a format similar to this.

Conclusion

The present research should serve as a jumping off point for future studies of this kind. It contributes to the literature on technology and aging by informing on the potential to lower levels of loneliness and increased levels of vitality for residents of RCC's. It also continues to build on the measurement literature, suggesting that measuring psychological constructs, such as depression and stress, may need to be treated differently with older populations. By integrating multiple approaches to understanding how relational maintenance and communal orientation operate within the context of RCC residents' use of virtual reality, this investigation adds new insights to the TRRL and helps to lay the

foundation for understanding relational processes and new technology for older adults. Importantly, this study led to new insights about how technology, such as virtual reality, could be used to improve the lives of one of our most vulnerable populations.

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Appendix

Table 1.

Rendever Videos in Order Per Week

Week 1

1. "Walk with Penguins"
2. "Surrounded by Elephants"
3. "Wild African Animals:
4. "Puppy Guide Dogs"

Week 2

1. "The Rockefeller Center Tree"
2. "European Christmas Market"
3. "Beethoven: Symphony No. 9 by Berlin Philharmonic"

Week 3

1. "Juno: Mission to Jupiter"
2. "Total Solar Eclipse
3. "Skydiving in Brazil"
4. "Inside an Airshow Airplane"

Week 4

1. "Farm Sanctuary"
2. "Snack Time with Cougars"

Note. Sessions for all four weeks were between 10-12 minutes and some weeks had more or fewer videos depending on their length.

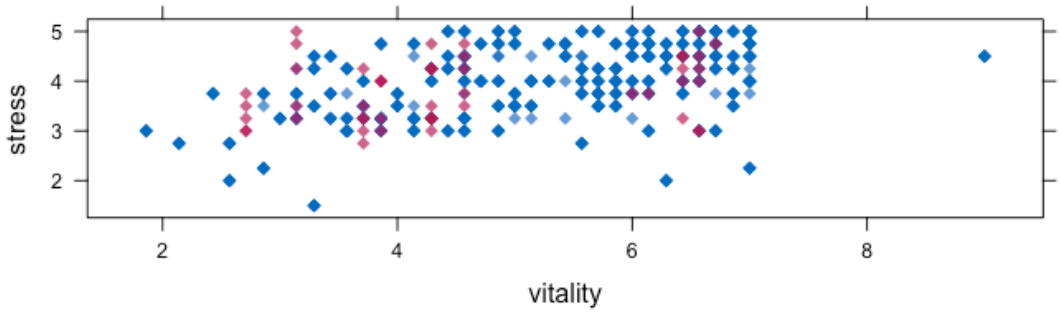
Table 2.

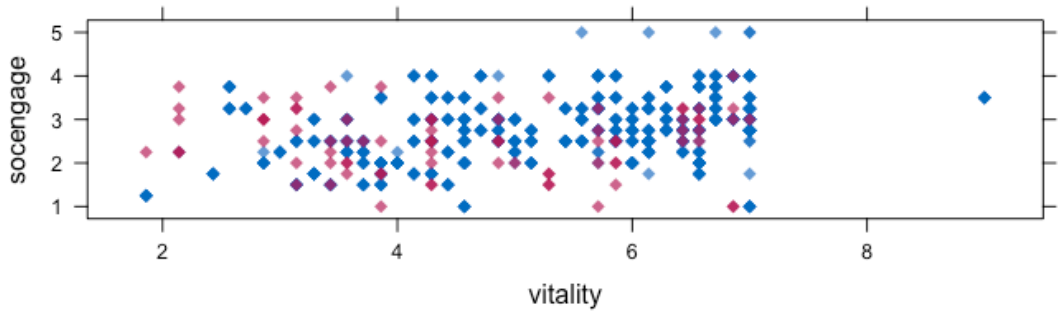
Results of Missingness Percentages.

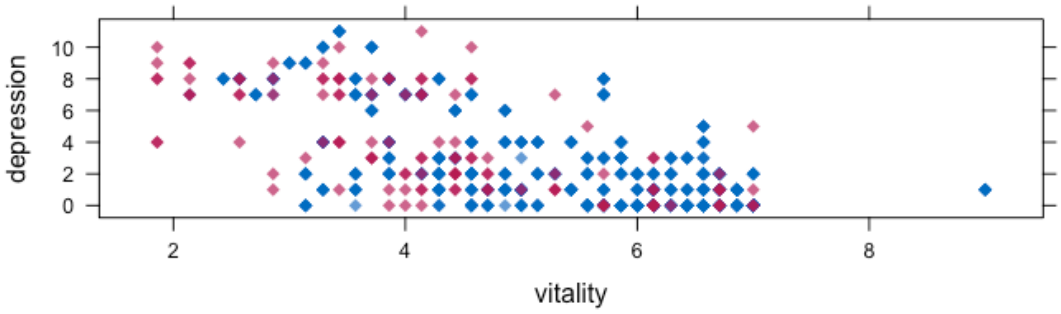
Variable	% Missing
1. Loneliness	3.5
2. Vitality	4.68
3. Communal orientation	7.6
4. Social activity	9.36
5. Depression	14.04
6. Emotional capital	17.54
7. Quality communication	47.37

Figures 3-10.

Comparing imputed data (magenta) to original data (blue) with vitality as a comparison variable







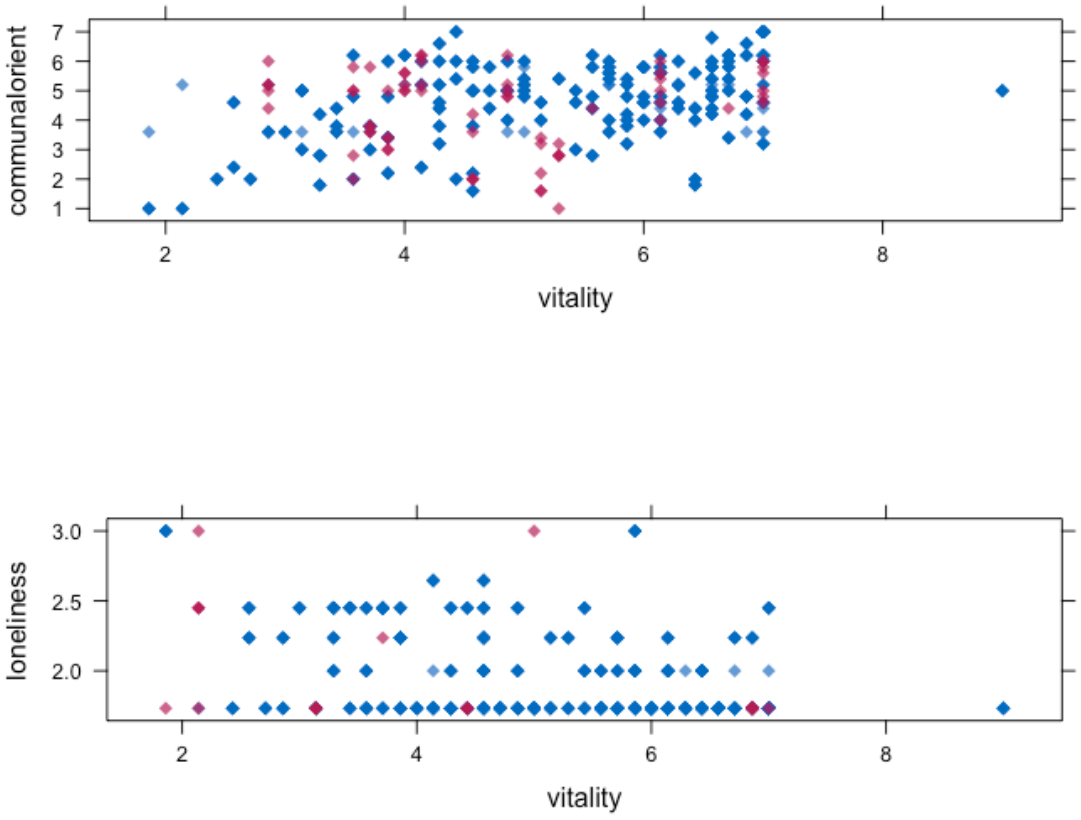


Figure 11.

Comparing the density of the imputed data (magenta) with the density of the original data (blue)

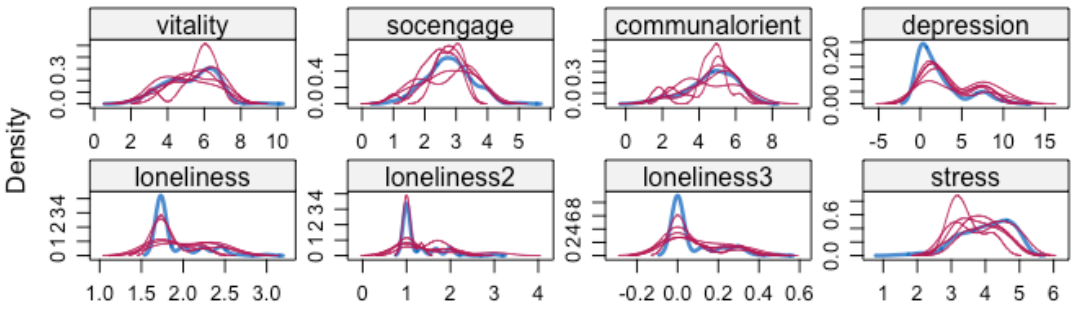


Figure 12. Comparing distribution of individual, imputed data points (magenta) to original data (blue)

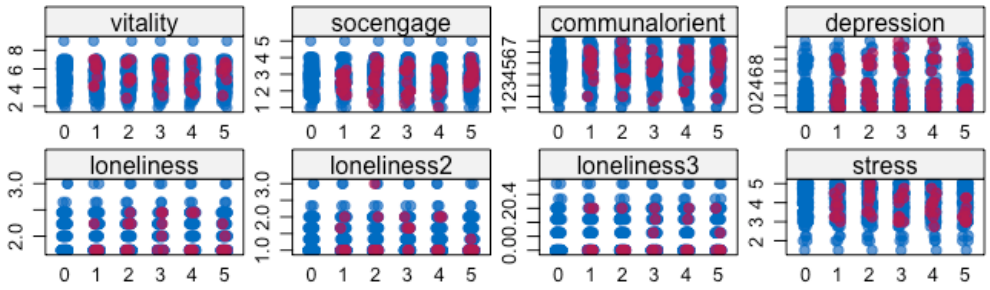


Table 3.

Means, standard deviations, and correlations with confidence intervals

Variable	M	SD	1	2	3	4	5
1. Vitality	5.25	1.33					
2. Stress	3.99	0.67	.41** [.28, .52]				
3. Depression	2.28	2.77	-.24** [-.37, -.10]	-.27** [-.40, -.14]			
4. Loneliness	2.71	1.23	.31** [.18, .44]	.24** [.10, .37]	-.27** [-.40, -.13]		
5. Social Activity	2.71	0.68	.32** [.18, .44]	.18* [.04, .32]	-.18* [-.31, -.04]	.27** [.14, .40]	
6. Comm Orient	4.70	1.32	.42** [.29, .53]	.14 [-.01, .27]	-.15* [-.29, -.01]	.50** [.39, .60]	.22** [.08, .36]

Note. M and SD are used to represent the grand mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.

Table 4.
T-tests Comparing Virtual Reality & Television Groups at Time One

	VR (n = 26)		TV (n = 21)		
Variable	*M*	*SD*	*M*	*SD*	*t*(44)
Communal Orientation[d]	4.35	1.42	4.84	1.25	1.33
Social Activity[b]	2.67	.80	2.96	.56	1.46
Vitality[d]	5.21	1.35	5.14	1.27	-0.19
Loneliness[e]	4.08	1.23	3.62	1.12	-1.34
Depression[a]	2.31	3.16	1.52	1.78	-1.78
Stress[c]	3.91	0.83	4.05	1.78	.61

[a] measured on scale from 1-3; [b]measured on scale from 1-4; [c]measured on scale from 1-5; [d]measured measured on scale from 1-7; [e]measured as a summed scale with the lowest value 3 and the highest value 9; * $p < .05$

Figure 13.

Histogram and QQ Plot of Bootstrapped Data for Social Activity

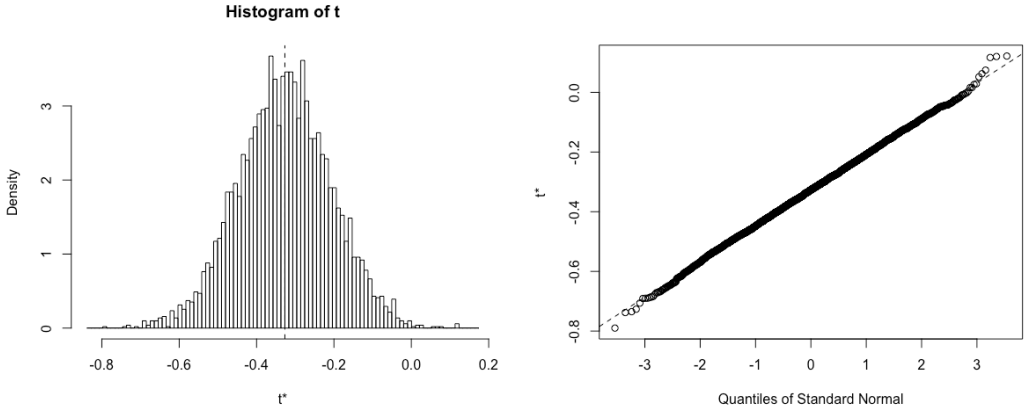


Figure 14.

Histogram and QQ Plot of Bootstrapped Data for Vitality

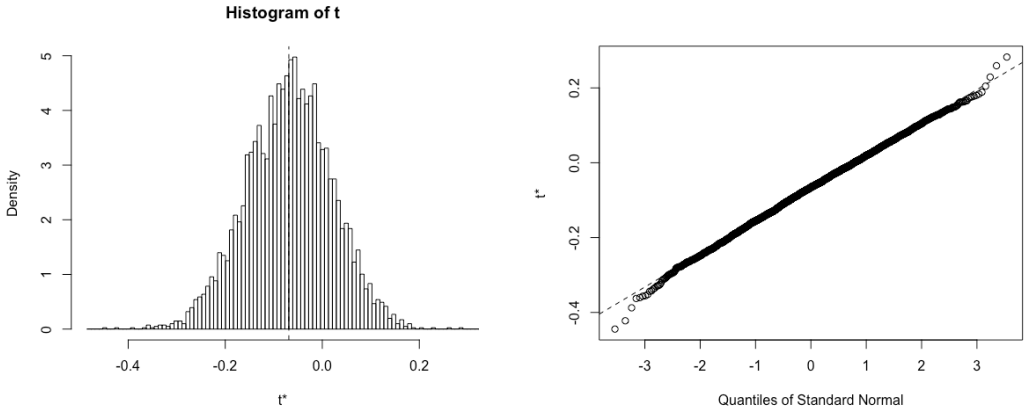


Figure 15.

Histogram and QQ Plot of Bootstrapped Data for Loneliness

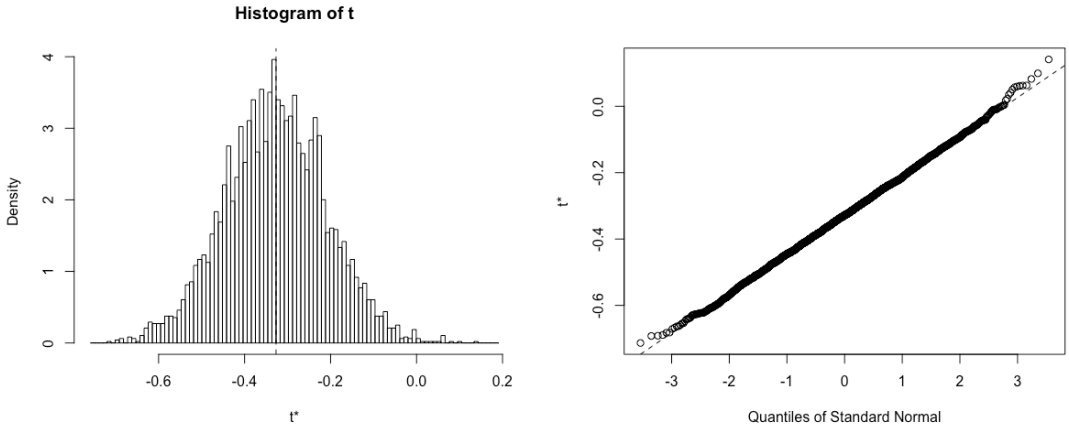


Figure 16. Histogram and QQ Plot of Bootstrapped Data for Depression

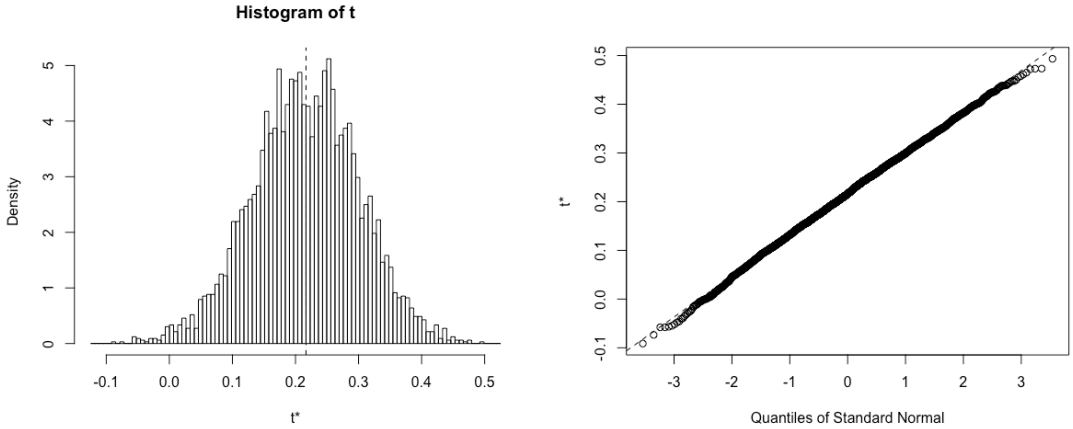


Table 5.
Indirect and Direct Within and Between Subjects Effects (Biased and Unbiased): Social Activity

Model	Beta	p	Lower B	Upper B
1. Population Covariance				
Covariance of Random Slopes	0.001		-0.017	0.022
2. Indirect Effects				
a. Unbiased Within-Subject Estimates	0.005	> .05	-0.051	0.037
b. Biased Within-Subject Estimates	0.003	> .05	-0.051	0.034
c. Bias in Within-Subjects Effect	0.001		0.000	0.025
3. Indirect Effects – Between-Subjects Estimates				
a. Unbiased Between-Subjects Estimates	-0.043	> .05	-0.087	0.006
b. Biased Between-Subjects Estimates	-0.043	> .05	-0.087	0.006
c. Bias in Between-Subjects Effects	0.000		0.000	0.000
4. Total Effect				
a. Unbiased Total Effect	**-0.216**	**< .05**	**-0.360**	**-0.067**
b. Biased Total Effect - X on Y (c path)	**-0.292**	**< .05**	**-0.396**	**-0.192**
c. Bias in Total Effect	0.074		0.003	0.198
5. Direct Effects				
a. VR → SA (c' path)	**-0.221**	**< .05**	**-0.354**	**-0.063**
b. Within-Subs. Effect of VR → CO (a path)	**-0.403**	**< .05**	**-0.618**	**-0.194**
c. Within-Subs. Effect of CO → SA (b path)†	-0.008	> .05	-0.086	0.118
d. Between-Subs. Effect of CO → SA (b path)‡	0.107	> .05	-0.016	0.188

CO = communal orientation, SA = Social Activity; † indicates that mediator is group-mean centered, ‡ indicates that the mediator is grand-mean centered. The bias in the indirect effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval, which is equal to the covariance between the random slopes for paths *a* and *b*. The bias in the total effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval. The difference between the biased and unbiased total effect is equal to $ab_{\text{unbiased}} - ab_{\text{biased}} + \sigma ab$

Table 6.
Indirect and Direct Within and Between Subjects Effects (Biased and Unbiased): Vitality

Model	Beta	p	Lower B	Upper B
1. Population Covariance				
Covariance of Random Slopes	0.000		-0.004	0.115
2. Indirect Effects: Within- Subjects Estimates				
a. Unbiased Within-Subject Estimates	-0.076	> .05	-0.137	0.103
b. Biased Within-Subject Estimates	-0.075	> .05	-0.158	0.028
c. Bias in Within-Subjects Effect	0.000		0.001	0.112
3. Indirect Effects: Between-Subjects Estimates				
a. Unbiased Between-Subjects Estimates	**-0.317**	**< .05**	**-0.452**	**-0.124**
b. Biased Between-Subjects Estimates	**-0.317**	**< .05**	**-0.452**	**-0.124**
c. Bias in Between-Subjects Effects	0.000		0.000	0.000
4. Total Effect				
a. Unbiased Total Effect	0.223	> .05	-0.021	0.497
b. Biased Total Effect - X on Y (c path)	-0.040	> .05	-0.238	0.155
c. Bias in Total Effect	0.263		0.093	0.493
5. Direct Effects				
a. VR → Vitality (c' path)	**0.298**	**< .05**	**0.022**	**0.506**
b. Within-Subs. Effect of VR → CO (a path)	**-0.403**	**< .05**	**-0.626**	**-0.190**
c. Within-Subs. Effect of CO → Vitality (b path)†	0.187	> .05	-0.074	0.334
d. Between-Subs. Effect of CO → Vitality (b path)‡	**0.786**	**< .05**	**0.491**	**0.862**

CO = communal orientation; † indicates that mediator is group-mean centered, ‡ indicates that the mediator is grand-mean centered. The bias in the indirect effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval, which is equal to the covariance between the random slopes for paths *a* and *b*. The bias in the total effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval. The difference between the biased and unbiased total effect is equal to $ab_{\text{unbiased}} - ab_{\text{biased}} + \sigma ab$

Table 7.
Indirect and Direct Within and Between Subjects Effects (Biased and Unbiased): Loneliness

Model	Beta	p	Lower B	Upper B
1. Population Covariance				
Covariance of Random Slopes	0.001		-0.060	0.021
2. Indirect Effects: Within-Subjects				
a. Unbiased Within-Subject Estimates	0.005	> .05	-0.060	0.051
b. Biased Within-Subject Estimates	0.003	> .05	-0.063	0.048
c. Bias in Within-Subjects Effect	0.001		0.000	0.024
3. Indirect Effects: Between-Subjects				
a. Unbiased Between-Subjects Estimates	-0.044	> .05	-0.116	0.016
b. Biased Between-Subjects Estimates	-0.044	> .05	-0.116	0.016
c. Bias in Between-Subjects Effects	0.000		0.000	0.000
4. Total Effect				
a. Unbiased Total Effect	**-0.253**	**< .05**	**-0.558**	**-0.038**
b. Biased Total Effect - X on Y (c path)	**-0.327**	**< .05**	**-0.563**	**-0.097**
c. Bias in Total Effect	0.074		0.004	0.218
5. Direct Effects				
a. VR → Loneliness (c' path)	**-0.258**	**< .05**	**-0.562**	**-0.036**
b. Within-Subs. Effect of VR → CO (a path)	-0.409	> .05	-0.926	-0.109
c. Within-Subs. Effect of CO → Loneliness (b path)†	-0.008	> .05	-0.091	0.113
d. Between-Subs. Effect of CO → Loneliness (b path)‡	0.107	> .05	-0.018	0.192

CO = communal orientation; † indicates that mediator is group-mean centered, ‡ indicates that the mediator is grand-mean centered. The bias in the indirect effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval, which is equal to the covariance between the random slopes for paths *a* and *b*. The bias in the total effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval. The difference between the biased and unbiased total effect is equal to $ab_{\text{unbiased}} - ab_{\text{biased}} + \sigma ab$

Table 8.
Indirect and Direct Within and Between Subjects Effects (Biased and Unbiased): Depression

Model	Beta	p	Lower B	Upper B
1. Population Covariance				
Covariance of Random Slopes	0.002		-0.015	0.011
2. Indirect Effects: Within-Subjects Estimates				
a. Unbiased Within-Subject Estimates	0.028	> .05	-0.008	0.056
b. Biased Within-Subject Estimates	0.026	> .05	-0.005	0.055
c. Bias in Within-Subjects Effect	0.002		0.000	0.015
3. Indirect Effects: Between Subjects Estimates				
a. Unbiased Between-Subjects Estimates	0.001	> .05	-0.017	0.030
b. Biased Between-Subjects Estimates	0.001	> .05	-0.017	0.030
c. Bias in Between-Subjects Effects	0.000		0.000	0.000
4. Total Effect				
a. Unbiased Total Effect	**0.133**	**< .05**	**0.054**	**0.203**
b. Biased Total Effect - X on Y (c path)	**0.114**	**< .05**	**0.052**	**0.173**
c. Bias in Total Effect	0.019		0.001	0.065
5. Direct Effects				
a. VR → Dep (c' path)	**0.104**	**< .05**	**0.042**	**0.171**
b. Within-Subs. Effect of VR → CO (a path)	**-0.403**	**< .05**	**-0.619**	**-0.188**
c. Within-Subs. Effect of CO → Dep (b path)†	-0.065	> .05	-0.115	0.014
d. Between-Subs. Effect of CO → Dep (b path)‡	-0.004	> .05	-0.067	0.040

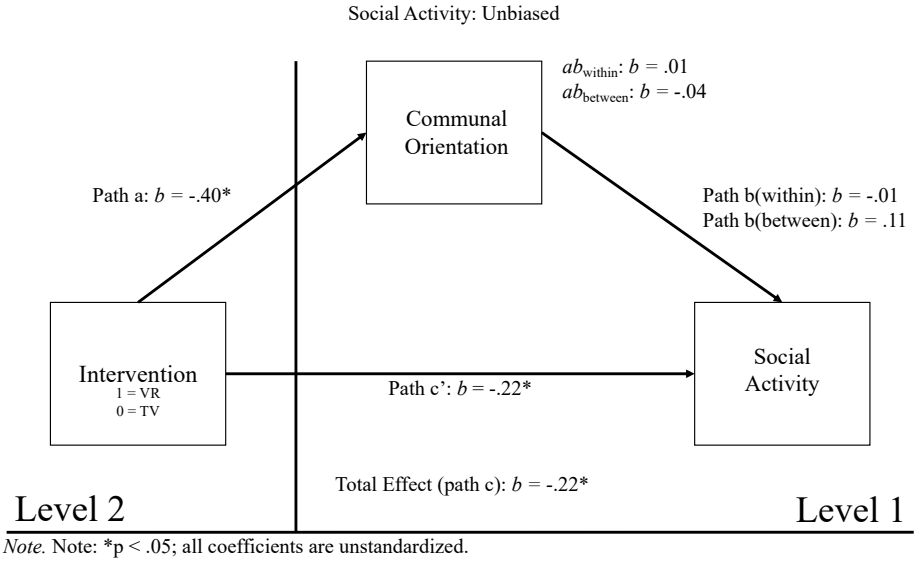
CO = communal orientation, Dep = Depression † indicates that mediator is group-mean centered, ‡ indicates that the mediator is grand-mean centered. The bias in the indirect effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval, which is equal to the covariance between the random slopes for paths *a* and *b*. The bias in the total effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval. The difference between the biased and unbiased total effect is equal to $ab_{\text{unbiased}} - ab_{\text{biased}} + \sigma ab$

Table 9.
Indirect and Direct Within and Between Subjects Effects (Biased and Unbiased): Stress

Model	Beta	p	Lower B	Upper B
1. Population Covariance				
Covariance of Random Slopes	0.002		-0.015	0.024
2. Indirect Effects				
a. Unbiased Within-Subject Estimates	-0.009	> .05	-0.076	0.036
b. Biased Within-Subject Estimates	-0.011	> .05	-0.076	0.030
c. Bias in Within-Subjects Effect	0.002		0.000	0.025
3. Indirect Effects: Between Subjects Estimates				
a. Unbiased Between-Subjects Estimates	-0.037	> .05	-0.083	0.007
b. Biased Between-Subjects Estimates	-0.037	> .05	-0.083	0.007
c. Bias in Between-Subjects Effects	0.000		0.000	0.000
4. Total Effect				
a. Unbiased Total Effect	-0.104	> .05	-0.283	0.048
b. Biased Total Effect - X on Y (c path)	-0.135	> .05	-0.280	0.005
c. Bias in Total Effect	0.031		0.001	0.125
5. Direct Effects				
a. VR → Stress (c' path)	-0.095	> .05	-0.256	0.052
b. Within-Subs. Effect of VR → CO (a path)	**-0.403**	**< .05**	**-0.620**	**-0.193**
c. Within-Subs. Effect of CO → Stress (b path)†	0.026	> .05	-0.072	0.166
d. Between-Subs. Effect of CO → Stress (b path)‡	0.093	> .05	-0.018	0.180

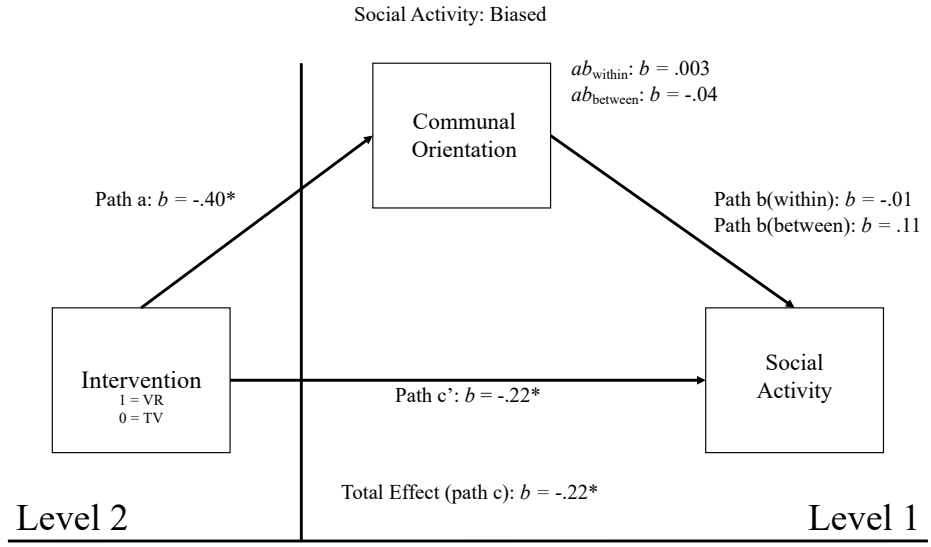
CO = communal orientation; † indicates that mediator is group-mean centered, ‡ indicates that the mediator is grand-mean centered. The bias in the indirect effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval, which is equal to the covariance between the random slopes for paths *a* and *b*. The bias in the total effect was calculated by subtracting the unbiased estimate and confidence interval from the biased estimate and confidence interval. The difference between the biased and unbiased total effect is equal to $ab_{\text{unbiased}} - ab_{\text{biased}} + \sigma ab$

Figure 17. Unbiased Model: Communal Orientation Mediating VR Intervention and Social Activity



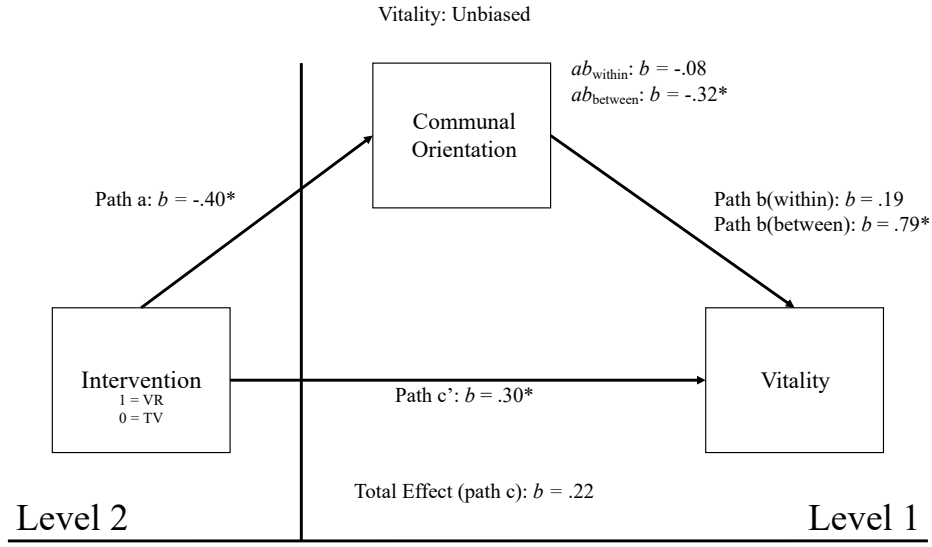
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 18. Biased Model: Communal Orientation Mediating VR Intervention and Social Activity



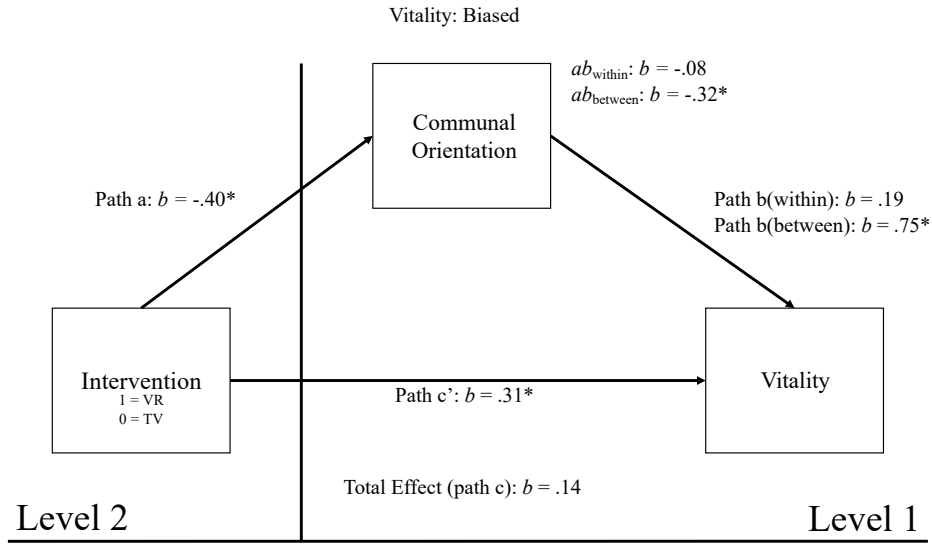
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 19. Biased Model: Communal Orientation Mediating VR Intervention and Vitality



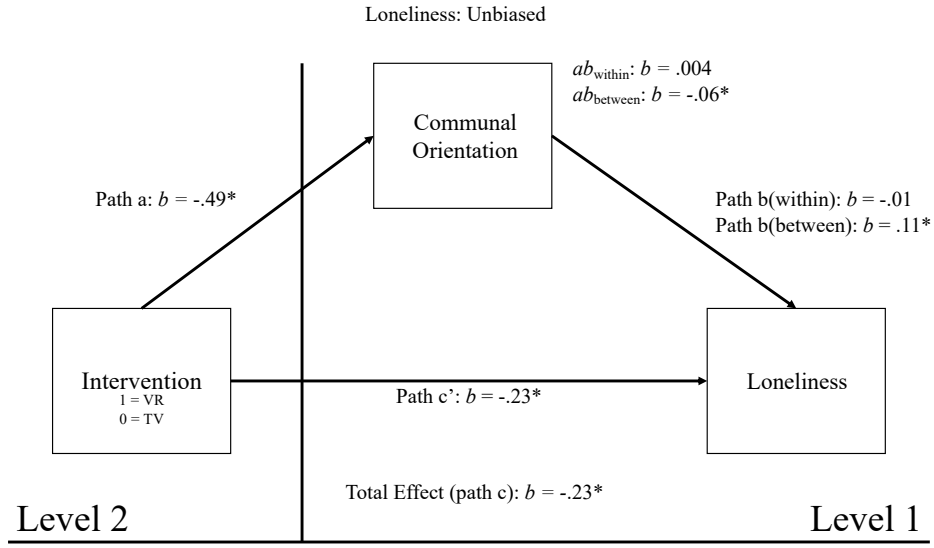
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 20. Biased Model: Communal Orientation Mediating VR Intervention and Vitality



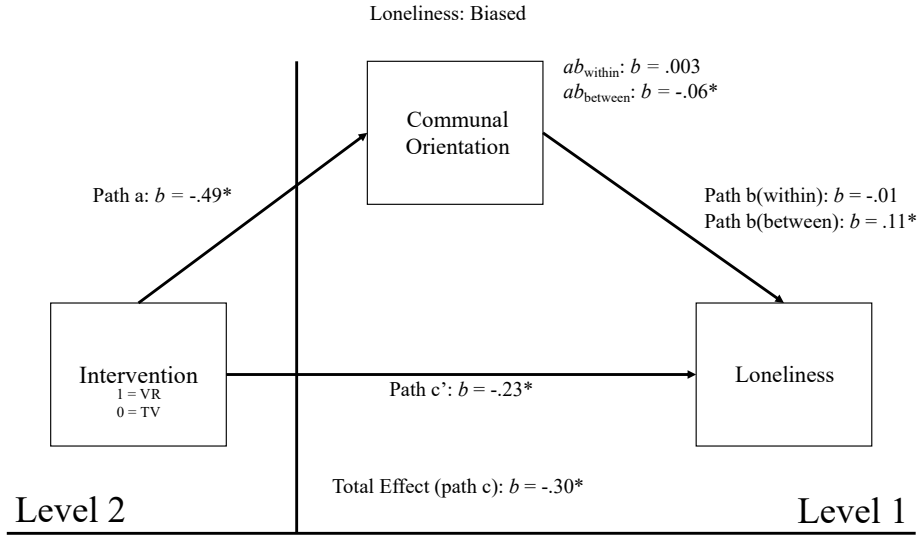
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 21. Unbiased Model: Communal Orientation Mediating VR Intervention and Loneliness



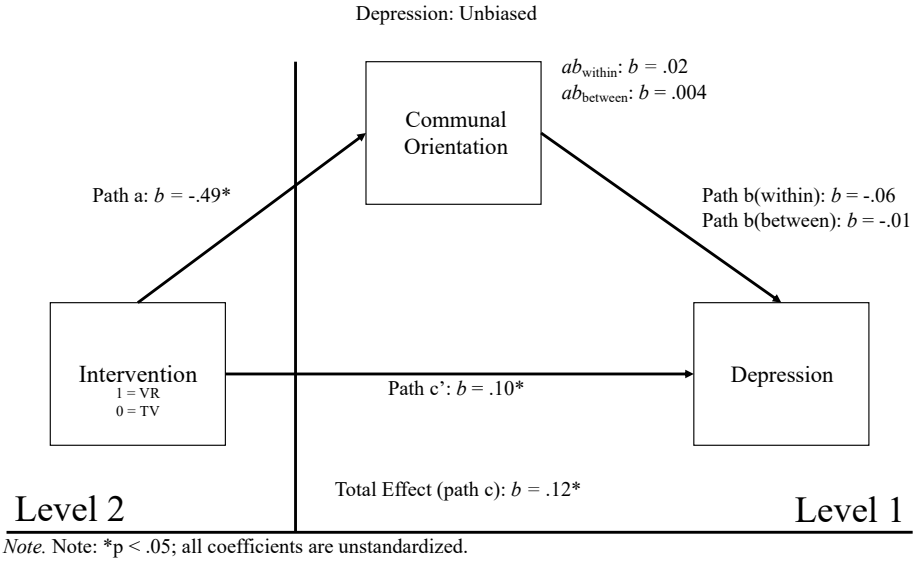
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 22. Biased Model: Communal Orientation Mediating VR Intervention and Loneliness



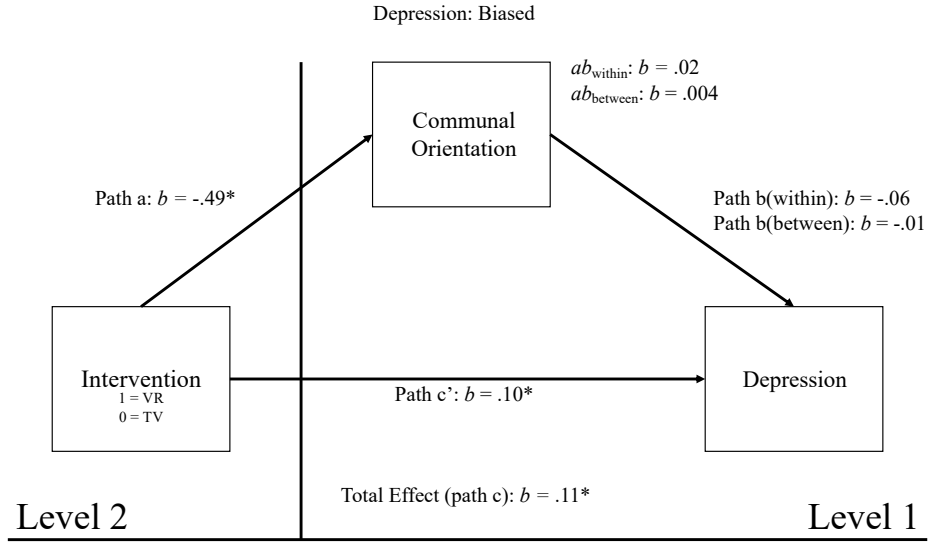
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 23. Unbiased Model: Communal Orientation Mediating VR Intervention and Depression



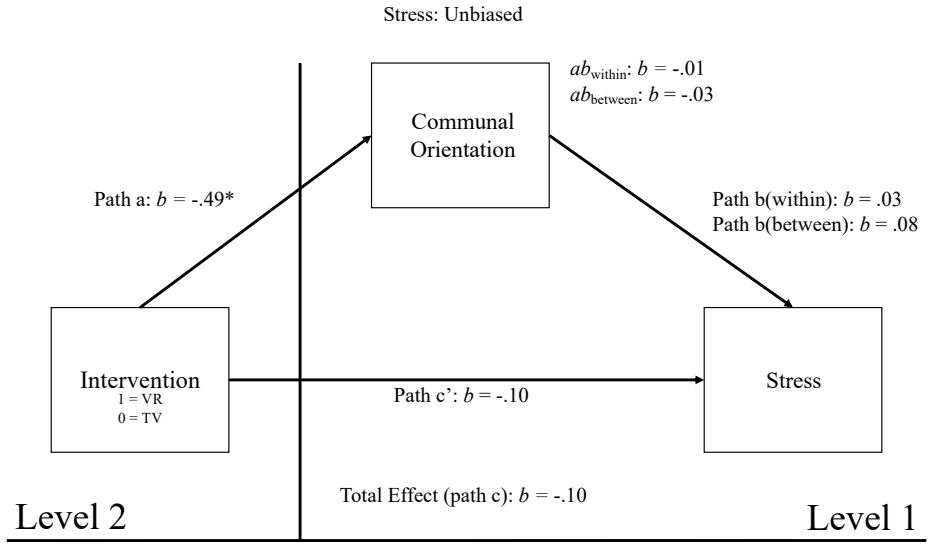
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 24. Biased Model: Communal Orientation Mediating VR Intervention and Depression



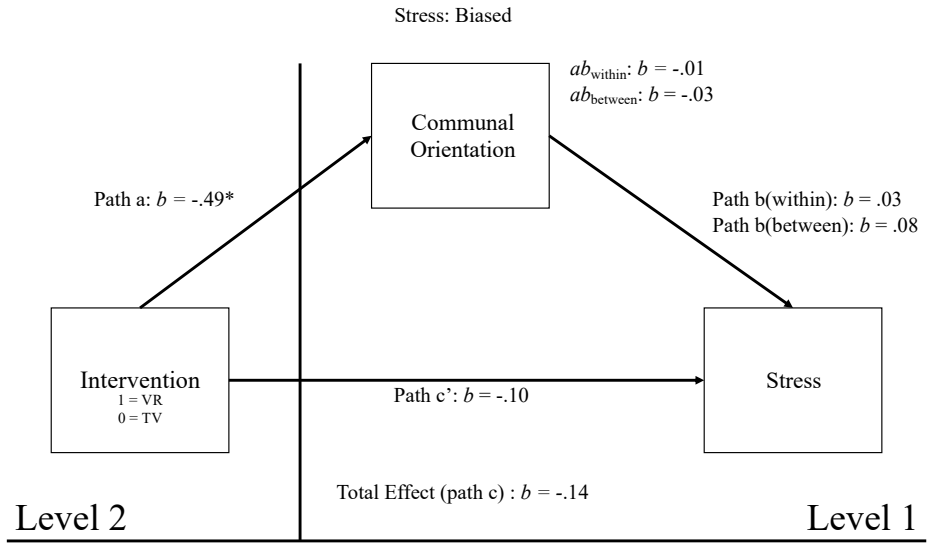
Note. Note: *p < .05; all coefficients are unstandardized.

Figure 25. Unbiased Model: Communal Orientation Mediating VR Intervention and Stress



Note. Note: *p < .05; all coefficients are unstandardized.

Figure 26. Biased Model: Communal Orientation Mediating VR Intervention and Stress



Note. Note: *p < .05; all coefficients are unstandardized.

Baseline Survey

UC SANTA BARBARA
DEPARTMENT OF COMMUNICATION

What is your participant identification number (given to you by the researcher)?

_____

What is your age?

_____

What is your biological sex?

- ○ Male
- ○ Female

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What is your ethnicity?

- ○ African American
- ○ Arab American
- ○ Asian American
- ○ Hispanic American
- ○ Native American
- ○ White (European American)
- ○ Other (Please specify)

_____

Approximately how long have you lived at Maravilla? (in years and/or months)

_____

What was the reason you moved into Maravilla? (i.e., a fall, voluntary)

_____

In driving time, how far away does your nearest family member live? Please provide the time in hours.

_____

Please think of the family member you consider yourself closest to and estimate how often you speak with them ON AVERAGE.

- ○ Everyday
- ○ Every other day
- ○ Every few days
- ○ Once a week
- ○ Once every other week
- ○ Once a month
- ○ Every couple of months
- ○ Every few months or less

How many residents at Maravilla do you consider close friends?

_____

What is your marital status?

- ○ Married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ Never married

If you are not married, are you in a romantic relationship?

- ○ Yes
- ○ No
- ○ I am unsure
- ○ Not applicable

Does your romantic partner live with you at Maravilla?

- ○ Yes
- ○ No
- ○ Not applicable

If your romantic partner lives with you at Maravilla, do you provide care for them?

- ○ Yes
- ○ No
- ○ Not applicable

Is there anyone in your group that you know very well?

- ○ Yes
- ○ No
- ○ I'm not sure

Is there anyone in your group that you have never met?

- ○ Yes
- ○ No
- ○ I'm not sure

The next set of questions will ask about your technology experience:

	Negative									Positive
How would you rate your level of experience with technology?	○	○	○	○	○	○	○	○	○	○
Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider of new technology or an early user of new technology?	○	○	○	○	○	○	○	○	○	○
How would you rate your ability to learn how to use new technologies?	○	○	○	○	○	○	○	○	○	○
How would you rate your overall level of trust in technology?	○	○	○	○	○	○	○	○	○	○

Think about the other Maravilla residents in your group for this study and indicate how much they have done each of the following actions over the past 30 days:

	Not at all		Sometimes		A great deal
Complimented me	○	○	○	○	○
Smiled at me	○	○	○	○	○
Greeted me when I came in the room	○	○	○	○	○
Enjoyed seeing me get enthusiastic about something	○	○	○	○	○
Said thank you when I did something for him/her	○	○	○	○	○
Made me laugh	○	○	○	○	○
Said something that made me feel good about myself	○	○	○	○	○

Next, please indicate your responses to the following questions keeping in mind your relationships at Maravilla:

	Hardly ever	Some of the time	Often
How often do you feel that you lack companionship?	○	○	○
How often do you feel left out?	○	○	○
How often do you feel isolated from others?	○	○	○

In general, how many close friends do you have at Maravilla? (People that you feel at ease with, can talk to about private matters, and can call on for help.)

- ○ At least one close friend
- ○ No close friends

Please indicate your access to and the adequacy of emotional support in the last 12 months.

- ○ I have at least one person in the assisted living home I can go to for emotional support
- ○ I do not have anyone in the assisted living home I can go to for emotional support or I have someone I can go to but the support is not adequate

If you need some extra help financially, could you count on anyone to help (i.e., by paying bills, housing costs, hospital visits, or providing you with food or clothes)?

- ○ Yes
- ○ No

Please indicate your responses to the following statements in terms of how they apply to you and your life at the present time:

	Not at all			Somewhat true			Very true
I feel alive and vital	○	○	○	○	○	○	○
I don't feel very energetic	○	○	○	○	○	○	○
Sometimes I feel so alive I just want to burst	○	○	○	○	○	○	○
I have energy and spirit	○	○	○	○	○	○	○
I look forward to each new day	○	○	○	○	○	○	○
I nearly always feel alert and awake	○	○	○	○	○	○	○
I feel energized	○	○	○	○	○	○	○

We would now like you to think about how you and the other residents at Maravilla handle stressful events or difficult times that arise. With that in mind, please indicate the best response that represents how you and the other residents at Maravilla handle stress and adversity (in general).
Next, please choose the best answer for how you felt over the past week:

	Yes	No
Are you basically satisfied with your life?	○	○
Have you dropped many of your activities and interests?	○	○
Do you feel that your life is empty?	○	○
Do you often get bored?	○	○
Are you in good spirits most of the time?	○	○
Are you afraid that something bad is going to happen to you?	○	○
Do you feel happy most of the time?	○	○
Do you feel helpless?	○	○
Do you prefer to stay in your room than going out and doing new things at Maravilla?	○	○
Do you feel that you have more problems with your memory than most?	○	○

Do you think that it is wonderful to be alive?	○	○
Do you feel pretty worthless the way you are now?	○	○
Do you feel full of energy?	○	○
Do you feel that your situation is hopeless?	○	○
Do you think that most people are better than you are?	○	○

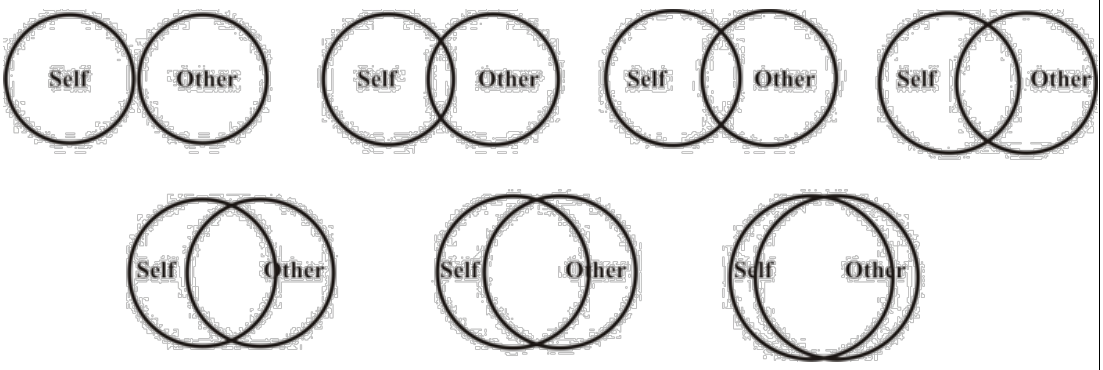
Please think about the other residents at Maravilla and indicate your response to the following questions:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I feel disconnected from the community around me.	○	○	○	○	○
Even around people I know at Maravilla, I don't feel that I really belong	○	○	○	○	○
I feel so distant from other residents at Maravilla.	○	○	○	○	○
I have no sense of togetherness with the other residents.	○	○	○	○	○
I don't feel like I can relate to anyone in the community.	○	○	○	○	○
I catch myself losing all sense of connectedness with the other residents.	○	○	○	○	○
Even among my friends at Maravilla, there is no sense of brother/sisterhood.	○	○	○	○	○
I don't feel I participate with anyone or any group at Maravilla.	○	○	○	○	○

Please reflect on your communication with other residents at Maravilla, in general, over the past month and indicate the quality of that communication:

	1	2	3	4	5	6	7	8	9	
attentive listening	○	○	○	○	○	○	○	○	○	poor listening
in-depth	○	○	○	○	○	○	○	○	○	superficial
smooth	○	○	○	○	○	○	○	○	○	difficult
guarded	○	○	○	○	○	○	○	○	○	open
a great deal of understanding	○	○	○	○	○	○	○	○	○	a great deal of misunderstanding
free of conflict	○	○	○	○	○	○	○	○	○	laden with conflict
emotionally supportive	○	○	○	○	○	○	○	○	○	emotionally unsupportive

Please indicate the picture that best describes your current relationship with your community at Maravilla IN GENERAL.



The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check or X how often you felt or thought a certain way.

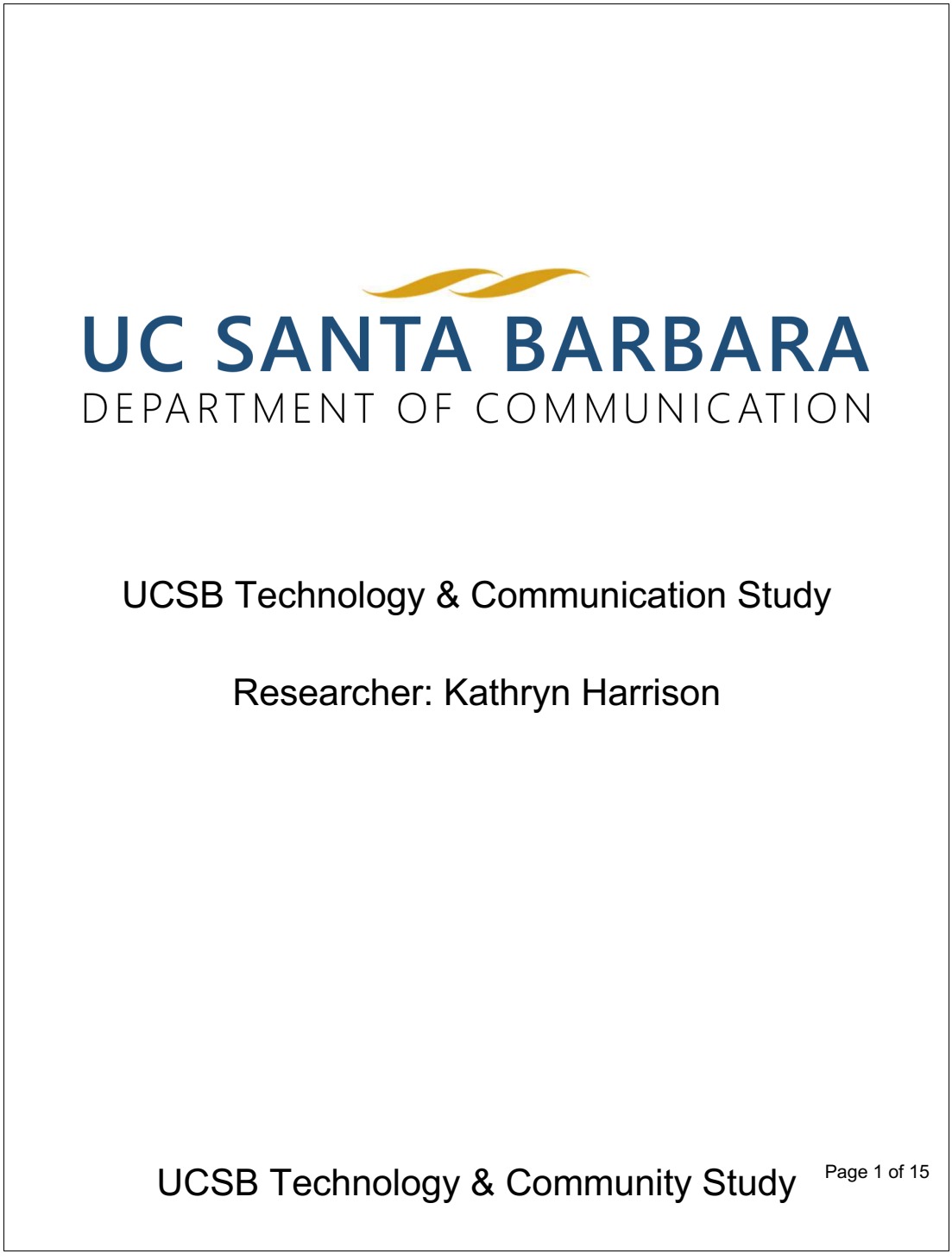
	Never	Almost never	Sometimes	Fairly often	Very often
In the last month, how often have you felt that you were unable to control the important things in your life?	○	○	○	○	○
In the last month, how often have you felt	○	○	○	○	○

confident about your ability to handle your personal problems?					
In the last month, how often have you felt that things were going your way?	○	○	○	○	○
In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	○	○	○	○	○

Please answer the following questions about Maravilla.

	Never	Sometimes	Often	Very often
How often do you attend social activities at Maravilla (such as meetings, recreational programs and so on)?	○	○	○	○
How often do you socialize with other residents at Maravilla?	○	○	○	○
How often do you attend social activities outside of Maravilla (such as church activities, going to movies or concerts, and so on)?	○	○	○	○
How often do you socialize with people outside of Maravilla?	○	○	○	○

Second, Third, and Fourth Surveys



What is your participant identification number (given to you by the researcher)?

_____

How many residents at Maravilla do you consider close friends?

_____

Has your marital status or romantic partnership changed since the last survey?

- ○ Yes
- ○ No

If so, how?

_____

Since your last virtual experience, how much have you talked about the experience with other members of the Maravilla community (IN GENERAL)?

- ○ Not at all
- ○ A little
- ○ A moderate amount
- ○ A lot
- ○ I can't stop talking about it

Since your last virtual experience, how much have you talked about the experience with other members of YOUR GROUP FOR THIS STUDY?

- ○ Not at all
- ○ A little
- ○ A moderate amount
- ○ A lot
- ○ I can't stop talking about it

If you have talked about your last virtual experience, who did you talk to about it? (Check all that apply)

- ○ The other residents in my group
- ○ Other residents outside of my group
- ○ The staff
- ○ My family
- ○ Other (please specify) _____

If you have talked about your last virtual experience with your community at Maravilla, please rate the extent to which the talk was positive or negative ON AVERAGE.

- ○ Extremely negative
- ○ Moderately negative
- ○ Slightly negative
- ○ Neither positive nor negative
- ○ Slightly positive (see next page for more options)

- ○ Moderately positive
- ○ Extremely positive

If you have talked about your last virtual experience with your GROUP IN THIS STUDY WITH YOU, please rate the extent to which the talk was positive or negative ON AVERAGE.

- ○ Extremely negative
- ○ Moderately negative
- ○ Slightly negative
- ○ Neither positive nor negative
- ○ Slightly positive
- ○ Moderately positive
- ○ Extremely positive

Please answer the following questions about your experience with the virtual reality (VR) so far:

	Not at all									Extremely
I am satisfied with the virtual experience	○	○	○	○	○	○	○	○	○	○
I am interested in the virtual experience	○	○	○	○	○	○	○	○	○	○
The virtual experience is uncomfortable	○	○	○	○	○	○	○	○	○	○
The virtual experience irritates my eyes	○	○	○	○	○	○	○	○	○	○
The virtual experience gives me anxiety	○	○	○	○	○	○	○	○	○	○
The virtual experience makes me feel fatigued	○	○	○	○	○	○	○	○	○	○
The virtual experience is easy to use	○	○	○	○	○	○	○	○	○	○
I feel secure when participating in the virtual experience	○	○	○	○	○	○	○	○	○	○

Please answer the following questions about your experience with the virtual reality (VR) so far:

	Very dissatisfied/not at all likely									Very satisfied/very likely
How likely are you to consider using the virtual experience system in the future?	○	○	○	○	○	○	○	○	○	○
How likely are you to recommend to a friend or family member that they consider trying the virtual experience system in the future?	○	○	○	○	○	○	○	○	○	○

How much fun did you find the virtual reality system?

No fun at all ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Extremely fun

To what extent did you feel nauseous during the virtual experience?

No nausea at all ○ Mild nausea ○ ○ Moderate nausea ○ Severe nausea ○ ○ Vomit ○

UCSB Technology & Community Study

Think about the other Maravilla residents in your group and indicate how much they have done each of the following actions over the past 7 days:

	Not at all		Sometimes		A great deal
Complimented me	○	○	○	○	○
Smiled at me	○	○	○	○	○
Greeted me when I came in the room	○	○	○	○	○
Enjoyed seeing me get enthusiastic about something	○	○	○	○	○
Said thank you when I did something for him/her	○	○	○	○	○
Made me laugh	○	○	○	○	○
Said something that made me feel good about myself	○	○	○	○	○

Next, please indicate your responses to the following questions regarding the past 7 days at Maravilla:

	Hardly ever	Some of the time	Often
How often have you felt that you lack companionship at Maravilla?	○	○	○
How often have you felt left out at Maravilla?	○	○	○
How often have you felt isolated from others at Maravilla?	○	○	○

In general, how many close friends do you have at Maravilla? (People that you feel at ease with, can talk to about private matters, and can call on for help.)

- ○ No close friends
- ○ At least one close friend
- ○ 2-3 close friends
- ○ 4-5 close friends
- ○ 5-6 close friends
- ○ 7 or more close friends

Please indicate your access to and the adequacy of emotional support in the last week.

- ○ I have at least one person at Maravilla I can go to for emotional support
- ○ I do not have anyone at Maravilla I can go to for emotional support
- ○ I have someone I can go to but the support is not adequate

If you need some extra help financially, could you count on anyone to help (e.g., by paying bills, housing costs, hospital visits, or providing you with food or clothes)?

- ○ Yes
- ○ No

Please indicate your responses to the following statements in terms of how they apply to you and your life at the present time:

	Not at all			Somewhat true			Very true
I feel alive and vital	○	○	○	○	○	○	○
I don't feel very energetic	○	○	○	○	○	○	○
Sometimes I feel so alive I just want to burst	○	○	○	○	○	○	○
I have energy and spirit	○	○	○	○	○	○	○
I look forward to each new day	○	○	○	○	○	○	○
I nearly always feel alert and awake	○	○	○	○	○	○	○
I feel energized	○	○	○	○	○	○	○

Next, please choose the best answer for how you felt over the past week:	Yes	No
Are you basically satisfied with your life?	○	○
Have you dropped many of your activities and interests?	○	○
Do you feel that your life is empty?	○	○
Do you often get bored?	○	○
Are you in good spirits most of the time?	○	○
Are you afraid that something bad is going to happen to you?	○	○
Do you feel happy most of the time?	○	○
Do you feel helpless?	○	○
Do you prefer to stay in your room rather than going out and doing new things at Maravilla?	○	○
Do you feel that you have more problems with your memory than most?	○	○
Do you think that it is wonderful to be alive?	○	○
Do you feel pretty worthless the way you are now?	○	○
Do you feel full of energy?	○	○
Do you feel that your situation is hopeless?	○	○

	Yes	No
Do you think that most people are better than you are?	○	○

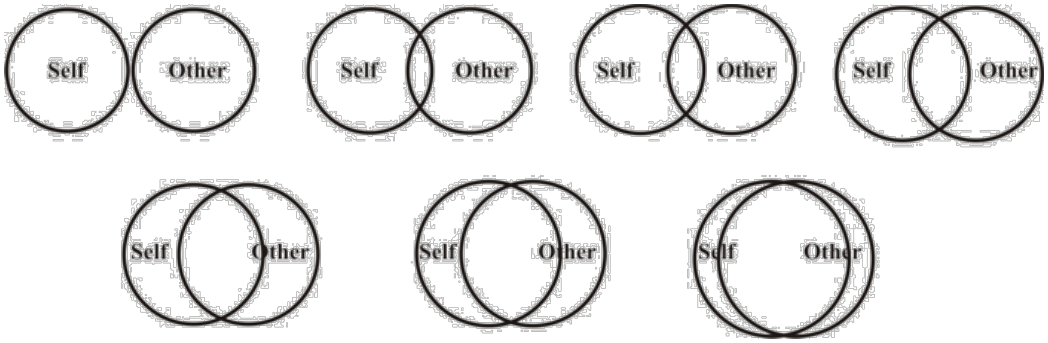
We would now like you to think about how you and the other residents at Maravilla handle stressful events or difficult times that arise. With that in mind, please indicate the best response that represents how you and the other residents at Maravilla handle stress and adversity (in general).

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
The other Maravilla residents and I will always get through our stress together.	○	○	○	○	○	○	○
The other residents at Maravilla and I address our relationship problems as a team.	○	○	○	○	○	○	○
The other residents at Maravilla and I are "in it together" when it comes to life's challenges.	○	○	○	○	○	○	○
The other residents at Maravilla are there for me in times of need.	○	○	○	○	○	○	○
The other residents at Maravilla protect me or look out for me in times of stress.	○	○	○	○	○	○	○

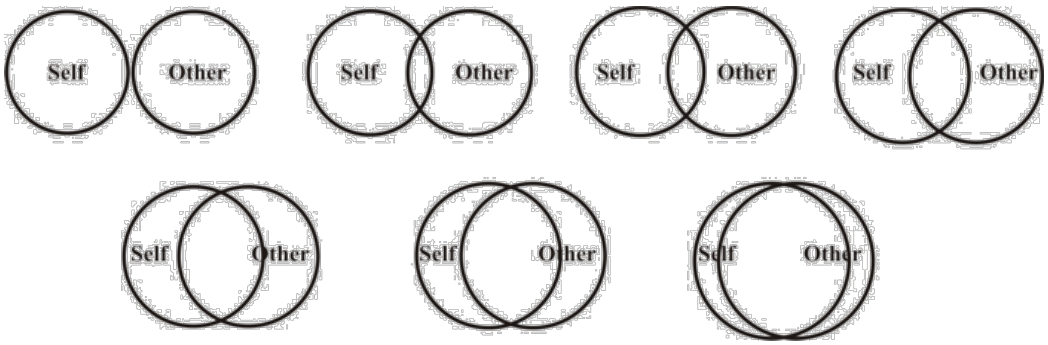
Please reflect on your verbal and nonverbal interactions with other residents IN YOUR GROUP FOR THIS STUDY, in general, over the past week and indicate the quality of their communication (e.g., do you feel like your other group members have listened attentively or poorly to you over the past week?):

	1	2	3	4	5	6	7	8	9	
poor listening	○	○	○	○	○	○	○	○	○	attentive listening
superficial	○	○	○	○	○	○	○	○	○	in-depth
difficult	○	○	○	○	○	○	○	○	○	smooth
open	○	○	○	○	○	○	○	○	○	guarded
a great deal of misunderstanding	○	○	○	○	○	○	○	○	○	a great deal of understanding
laden with conflict	○	○	○	○	○	○	○	○	○	free of conflict
emotionally unsupportive	○	○	○	○	○	○	○	○	○	emotionally supportive

Please indicate by circling the picture that best describes your current relationship with your community at Maravilla IN GENERAL.



Please indicate by circling the picture that best describes your current relationship with YOUR GROUP FOR THIS STUDY.



The questions in this scale ask you about your feelings and thoughts during the last 7 days. In each case, please indicate with a check how often you felt or thought a certain way.

	Never	Almost never	Sometimes	Fairly often	Very often
In the last week, how often have you felt that you were unable to control the important things in your life?	○	○	○	○	○
In the last week, how often have you felt confident about your ability to handle your personal problems?	○	○	○	○	○
In the last week, how often have you felt that things were going your way?	○	○	○	○	○
In the last week, how often have you felt difficulties were piling up so high that you could not overcome them?	○	○	○	○	○

Please answer the following questions about Maravilla:

	Never	Sometimes	Often	Very often
In the last week, how often did you attend social activities at Maravilla (such as meetings, recreational programs and so on)?	○	○	○	○
In the last week, how often did you socialize with other residents at Maravilla?	○	○	○	○
In the last week, how often did you attend social activities outside of Maravilla (such as church activities, going to movies or concerts, and so on)?	○	○	○	○

	Never	Sometimes	Often	Very often
In the last week, how often did you socialize with people outside of Maravilla?	○	○	○	○

Thank you!

R Code for Analyses

```
library(dplyr)
library(tidyr)
library(corrr)
library(mice)
library(stringr)
library(lme4)
library(ggplot2)
library(boot)
library(sjPlot)
library(DescTools)
library(psy)
library(apaTables)
library(haven)

setwd("~/Desktop/Dissertation")
dissdata <- read_sav("DissData_WORKING.sav")

#flipping from long to wide
make_wide <- function(input_df, col_name) {
  week_prefix <- paste0('week_', col_name, '_')

  wide_df <- input_df %>%
    mutate(week = paste0(week_prefix, week)) %>%
    spread(week, col_name) %>%
    select(sub_id,
           intervention,
```

```
              paste0(week_prefix, '1'),
              paste0(week_prefix, '2'),
              paste0(week_prefix, '3'),
              paste0(week_prefix, '4'),
              everything())

    return(wide_df)
  }

  make_long <- function(input_df, col_name) {
    week_prefix <- paste0('week_', col_name, '_')

    long_df <- gather(input_df,
                      key = 'week',
                      value = value_name,
                      paste0(week_prefix,
'1'):paste0(week_prefix, '4'))
    names(long_df)[names(long_df) == 'value_name'] <-
col_name

    long_df$week <- gsub(paste0(week_prefix, '1'), '1',
long_df$week)
    long_df$week <- gsub(paste0(week_prefix, '2'), '2',
long_df$week)
    long_df$week <- gsub(paste0(week_prefix, '3'), '3',
long_df$week)
```

```
    long_df$week <- gsub(paste0(week_prefix, '4'), '4',
long_df$week)

    long_df <- long_df %>% arrange(sub_id)

    return(long_df)
  }

  load_columns <- function(src_df, dest_df, src_col_name,
dest_col_name, limit) {
    for (i in 1:limit) {
      src <- paste(src_col_name, i, sep='')
      dest <- paste(dest_col_name, '_', i, sep='')

      dest_df[dest] <- src_df[src]
    }

    return(dest_df)
  }

  impute <- function(input_df) {
    # Only get the weeks to impute
    imputed_df <- mice(input_df[,c(3, 4, 5, 6)], m = 1, seed
= 5, meth = "pmm")

    #Diagnostic checking
    summary(imputed_df)
```

```
    # FIXME: Parameterize this
    #print(xyplot(imputed_df, week_comm_orientation_all_2 ~
week_comm_orientation_all_3, pch = 18, cex = 1))
    print(densityplot(imputed_df))
    print(stripplot(imputed_df, pch = 20, cex = 1.2))

    imputed_df <- complete(imputed_df)

    # Add back the keys that were removed for imputation
    imputed_df$sub_id <- input_df$sub_id
    imputed_df$intervention <- input_df$intervention
    imputed_df <- imputed_df[, c(5, 6, 1, 2, 3, 4)]

    return(imputed_df)
  }

  relationship_df <- {}
  tech_experience_df <- {}
  social_activity_df <- {}
  social_activity_all_df <- {}
  comm_orientation_all_df <- {}
  rec_loneliness_avg_df <- {}
  loneliness_all_df <- {}
  log_depression_df <- {}
  stress_df <- {}
  stress_all_df <- {}
  quality_comm_df <- {}
```

```
  vitality_df <- {}
  control_df <- {}
  emo_cap_df <- {}
  community_df <-{}
  ux_df <- {}
  depression_all_df <- {}

  load_data <- function() {
    dissdata <- read.csv("dissdata_filledin.csv")

    keys_df <- data.frame(
      'week' = dissdata$Week,
      'sub_id' = dissdata$subid,
      'intervention' = dissdata$Intervention
    )

    var_start_index <- ncol(keys_df) + 1

    relationship_df <<- data.frame(keys_df)
    relationship_df$marital_status <<- dissdata$maritalstatus
    relationship_df$relationship_status <<-
dissdata$relationstatus
    relationship_df$romantic_partner_live <<-
dissdata$rompartlive
    relationship_df$romantic_partner_care <<-
dissdata$rompartcare
```

```
    #IoS
    ios_df <<- data.frame(keys_df)
    ios_df$ios_mara <<- dissdata$IoSMara

    #Depression_all
    depression_all_df <<- data.frame(keys_df)
    depression_all_df$depression_all <<-
dissdata$depression_all

    # socialactivity aka socialengagement
    social_activity_df <<- data.frame(keys_df)
    social_activity_df <<- load_columns(dissdata,
social_activity_df, 'socialactivity', 'social_activity', 4)
    social_activity_all_df <<- data.frame(keys_df)
    social_activity_rows <-
as.data.frame.list(social_activity_df[,
c(var_start_index:ncol(social_activity_df))])
    social_activity_all_df$social_activity_all <<-
rowMeans(social_activity_rows)
    head(social_activity_all_df)

    ux_df <<- data.frame(keys_df)
    ux_df$ux_all <<- dissdata$ux_all

    # communalorientation
    comm_orientation_all_df <<- data.frame(keys_df)
```

```
    comm_orientation_all_df$comm_orientation_all <-
dissdata$communalorient_all
    # TODO: Find mean of this
    #comm_orientation_df <<- load_columns(dissdata,
comm_orientation_df, 'communaloriet', 'comm_orientation', 5)

    # recloneliness_avg
    rec_loneliness_avg_df <<- data.frame(keys_df)
    rec_loneliness_avg_df$rec_loneliness_avg <<-
dissdata$recloneliness_avg

    log_loneliness_avg_df <<- data.frame(keys_df)
    log_loneliness_avg_df$log_loneliness_avg <<-
dissdata$logloneliness_avg

    loneliness_all_df <<- data.frame(keys_df)
    loneliness_all_df$loneliness_all <<-
dissdata$lonelinessall

    # logdepression
    log_depression_df <<- data.frame(keys_df)
    log_depression_df$log_depression <<-
dissdata$logdepression

    # stress
    stress_df <<- data.frame(keys_df)
```

```
    stress_df <<- load_columns(dissdata, stress_df, 'stress',
'stress', 4)
    stress_all_df <<- data.frame(keys_df)
    stress_rows <- as.data.frame.list(stress_df[,
c(var_start_index:ncol(stress_df))])
    stress_all_df$stress_all <<- rowMeans(stress_rows)

    # vitality
    vitality_df <<- data.frame(keys_df)
    vitality_df$vitality <<- dissdata$vitality_all

    # qualcomm
    quality_comm_df <<- data.frame(keys_df)
    quality_comm_df <<- load_columns(dissdata,
quality_comm_df, 'qualcomm', 'quality_comm', 7)

    #emotionl cap
    emo_cap_df <<-data.frame(keys_df)
    emo_cap_df$emo_cap_all <<- dissdata$emotionalcap_all

    #community
    community_df <<-data.frame(keys_df)
    community_df$community_all <<- dissdata$senseofcomm_all

    control_df <<- data.frame(keys_df)
    control_df$time_at_mara <<- dissdata$timeatMara
    control_df$reasons_for_mara <<- dissdata$reasonforMara
```

```
    control_df$family_close <<- dissdata$familyclose
    control_df$family_talk <<- dissdata$familytalk
    control_df$friends <<- dissdata$friendsMara
    control_df$staff <<- dissdata$staffMara
    control_df$tech_experience <<- dissdata$techexp_all
    control_df$group_know <<- dissdata$groupknowwell
    control_df$group_know2 <<- dissdata$`groupknowwell#`
    control_df$group_stranger <<- dissdata$groupstranger
    control_df$group_stranger2 <<- dissdata$`groupstranger#
    control_df$marital_status <<- dissdata$maritalstatus
    control_df$relationship_status <<-
dissdata$relationstatus
    control_df$romantic_partner_live <<- dissdata$rompartlive
    control_df$romantic_partner_care <<- dissdata$rompartcare
    control_df$ux_all <<- dissdata$ux_all`
  }

  load_data()

  ios_df_wide <- make_wide(ios_df, 'ios_mara')
  ios_df_imputed <- impute(ios_df_wide)
  ios_df <- make_long(ios_df_imputed, 'ios_mara')

  depression_all_df_wide <- make_wide(depression_all_df,
'depression_all')
  depression_all_df_imputed <- impute(depression_all_df_wide)
```

```
  depression_all_df <- make_long(depression_all_df_imputed,
'depression_all')

  emo_cap_df_wide <- make_wide(emo_cap_df, 'emo_cap_all')
  emo_cap_df_imputed <- impute(emo_cap_df_wide)
  emo_cap_df <- make_long(emo_cap_df_imputed, 'emo_cap_all')

  community_df_wide <- make_wide(community_df,
'community_all')
  community_df <- make_long(community_df_wide,
'community_all')

  vitality_df_wide <- make_wide(vitality_df, 'vitality')
  vitality_df_imputed <- impute(vitality_df_wide)
  vitality_df <- make_long(vitality_df_imputed, 'vitality')

  log_depression_df_wide <- make_wide(log_depression_df,
'log_depression')
  log_depression_df_imputed <- impute(log_depression_df_wide)
  log_depression_df <- make_long(log_depression_df_imputed,
'log_depression')

  rec_loneliness_avg_df_wide <-
make_wide(rec_loneliness_avg_df, 'rec_loneliness_avg')
  rec_loneliness_avg_df_imputed <-
impute(rec_loneliness_avg_df_wide)
```

```
  rec_loneliness_avg_df <-
make_long(rec_loneliness_avg_df_imputed, 'rec_loneliness_avg')

  log_loneliness_avg_df_wide <-
make_wide(log_loneliness_avg_df, 'log_loneliness_avg')
  log_loneliness_avg_df_imputed <-
impute(log_loneliness_avg_df_wide)
  log_loneliness_avg_df <-
make_long(log_loneliness_avg_df_imputed, 'log_loneliness_avg')

  loneliness_all_df_wide <- make_wide(loneliness_all_df,
'loneliness_all')
  loneliness_all_df_imputed <- impute(loneliness_all_df_wide)
  loneliness_all_df <- make_long(loneliness_all_df_imputed,
'loneliness_all')

  comm_orientation_all_df_wide <-
make_wide(comm_orientation_all_df, 'comm_orientation_all')
  comm_orientation_all_df_imputed <-
impute(comm_orientation_all_df_wide)
  comm_orientation_all_df <-
make_long(comm_orientation_all_df_imputed,
'comm_orientation_all')

  stress_all_df_wide <- make_wide(stress_all_df,
'stress_all')
  stress_all_df_imputed <- impute(stress_all_df_wide)
```

```
  stress_all_df <- make_long(stress_all_df_imputed,
'stress_all')

  social_activity_all_df_wide <-
make_wide(social_activity_all_df, 'social_activity_all')
  social_activity_all_df_imputed <-
impute(social_activity_all_df_wide)
  social_activity_all_df <-
make_long(social_activity_all_df_imputed,
'social_activity_all')

  joined_df <- inner_join(x = vitality_df, y =
log_depression_df, by = c('sub_id', 'intervention', 'week'))
  joined_df <- inner_join(x = joined_df, y =
rec_loneliness_avg_df, by = c('sub_id', 'intervention',
'week'))
  joined_df <- inner_join(x = joined_df, y =
log_loneliness_avg_df, by = c('sub_id', 'intervention',
'week'))
  joined_df <- inner_join(x = joined_df, y =
loneliness_all_df, by = c('sub_id', 'intervention', 'week'))
  joined_df <- inner_join(x = joined_df, y =
comm_orientation_all_df, by = c('sub_id', 'intervention',
'week'))
  joined_df <- inner_join(x = joined_df, y = stress_all_df,
by = c('sub_id', 'intervention', 'week'))
```

```
  joined_df <- inner_join(x = joined_df, y =
social_activity_all_df, by = c('sub_id', 'intervention',
'week'))
  joined_df <- inner_join(x = joined_df, y = emo_cap_df, by =
c('sub_id', 'intervention', 'week'))
  joined_df <- inner_join(x = joined_df, y = community_df, by
= c('sub_id', 'intervention', 'week'))
  joined_df <- inner_join(x = joined_df, y = ios_df, by =
c('sub_id', 'intervention', 'week'))
  joined_df <- inner_join(x = joined_df, y =
depression_all_df, by = c('sub_id', 'intervention', 'week'))

  #Removing people with only one time point
  cleaned_df <- subset(joined_df, sub_id != 'A4' & sub_id !=
'B5' & sub_id != 'F1')
  ios_df <- subset(ios_df, sub_id != 'A4' & sub_id != 'B5' &
sub_id != 'F1')

  #Dummy Coding Intervention
  cleaned_df$intervention <- gsub('I', '1',
cleaned_df$intervention)
  cleaned_df$intervention <- gsub('C', '0',
cleaned_df$intervention)

  cleaned_control_df <- subset(control_df, week == 1)
  cleaned_control_df <- within(cleaned_control_df,
rm('week'))
```

```
  cleaned_relationship_df <- subset(relationship_df, week ==
1)
  cleaned_relationship_df <- within(cleaned_relationship_df,
rm('week'))
  head(cleaned_relationship_df)

  cleaned_control_df$intervention <- gsub('I', '1',
cleaned_control_df$intervention)
  cleaned_control_df$intervention <- gsub('C', '0',
cleaned_control_df$intervention)

  cleaned_relationship_df$intervention <- gsub('I', '1',
cleaned_control_df$intervention)
  cleaned_relationship_df$intervention <- gsub('C', '0',
cleaned_control_df$intervention)

  ios_df$intervention <- gsub('I', '1', ios_df$intervention)
  ios_df$intervention <- gsub('C', '0', ios_df$intervention)

  #adding in control vars to dataset
  my_df <- inner_join(x = cleaned_control_df, y = cleaned_df,
by = c('sub_id', 'intervention'))
  my_df <- inner_join(my_df, y = cleaned_relationship_df, by
= c('sub_id', 'intervention'))
```

```
  apa.cor.table(my_df, filename="Table1_APA.doc",
table.number=2)
  corr_table <-cbind(
    'Vitality' = my_df$vitality,
    'Stress' = my_df$stress_all_win,
    'Depression' = my_df$log_depression,
    'Loneliness' = my_df$rec_loneliness_avg_win,
    'Social Activity' = my_df$social_activity_all_win,
    'Communal Orienation' = my_df$comm_orientation_all_win
  )
  apa.cor.table(corr_table, filename="Table2_APA.doc",
table.number=2)

  social_activity_only <- subset(dissdata, select =
c(socialactivity1:socialactivity4))
  cronbach(social_activity_only)
  mean(my_df$social_activity_only)
  sd(my_df$social_activity_only)

  stress_only <- subset(dissdata, select =
c(stress1:stress4))
  cronbach(stress_only)
  mean(my_df$stress_only)
  sd(my_df$stress_only)

  ###Communal Orientation - VR
  CO_t1_mean_int <- my_df %>%
```

```
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(meanCO = mean(comm_orientation_all_win))
CO_t1_mean_int

CO_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(comm_orientation_all_win))
CO_t1_sd_int

#TV
CO_t1_mean_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(meanCO = mean(comm_orientation_all_win))
CO_t1_mean_tv

CO_t1_sd_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(comm_orientation_all_win))
CO_t1_sd_tv

###Social Activity###
SA_t1_mean_int <- my_df %>%
  filter(intervention == 1) %>%
```

```
  filter(week == 1) %>%
  summarize(meanSA = mean(social_activity_all_win))
SA_t1_mean_int

SA_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(social_activity_all_win))
SA_t1_sd_int

SA_t1_mean_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(meanSA = mean(social_activity_all_win))
SA_t1_mean_tv

SA_t1_sd_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(social_activity_all_win))
SA_t1_sd_tv

####Vitality
Vit_t1_mean_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(meanSA = mean(vitality))
```

```
Vit_t1_mean_int

Vit_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(vitality))
Vit_t1_sd_int

Vit_t1_mean_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(meanSA = mean(vitality))
Vit_t1_mean_tv

Vit_t1_sd_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(vitality))
Vit_t1_sd_tv

###Loneliness
Lon_t1_mean_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(meanSA = mean(loneliness_all))
Lon_t1_mean_int
```

```
Lon_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(loneliness_all))
Lon_t1_sd_int

Lon_t1_mean_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(meanSA = mean(loneliness_all))
Lon_t1_mean_tv

Lon_t1_sd_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(sdCO = sd(loneliness_all))
Lon_t1_sd_tv

###Depression
Dep_t1_mean_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(meanDep = mean(depression_all))
Dep_t1_mean_int

Dep_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
```

```
  filter(week == 1) %>%
  summarize(sdDep = sd(depression_all))
Dep_t1_sd_int

Dep_t1_mean_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(meanDep = mean(depression_all))
Dep_t1_mean_tv

Dep_t1_sd_tv <- my_df %>%
  filter(intervention == 0) %>%
  filter(week == 1) %>%
  summarize(sdDep = sd(depression_all))
Dep_t1_sd_tv

###Stress
Stress_t1_mean_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(meanStress = mean(stress_all))
Stress_t1_mean_int

Stress_t1_sd_int <- my_df %>%
  filter(intervention == 1) %>%
  filter(week == 1) %>%
  summarize(sdStress = sd(stress_all))
```

```
  Stress_t1_sd_int

  Stress_t1_mean_tv <- my_df %>%
    filter(intervention == 0) %>%
    filter(week == 1) %>%
    summarize(meanStress = mean(stress_all))
  Stress_t1_mean_tv

  Dep_t1_sd_tv <- my_df %>%
    filter(intervention == 0) %>%
    filter(week == 1) %>%
    summarize(sdDep = sd(depression_all))
  Dep_t1_sd_tv

  #####t-tests for week 1####
  week1_df <- my_df %>%
    filter(week == 1)
  t.test(comm_orientation_all~intervention, mu=0, conf=0.95,
var.eq=F, paired=F, data=week1_df)
  t.test(social_activity_all_win~intervention, mu=0,
conf=0.95, var.eq=F, paired=F, data=week1_df)
  t.test(vitality~intervention, mu=0, conf=0.95, var.eq=F,
paired=F, data=week1_df)
  t.test(loneliness_all~intervention, mu=0, conf=0.95,
var.eq=F, paired=F, data=week1_df)
  t.test(depression_all~intervention, mu=0, conf=0.95,
var.eq=F, paired=F, data=week1_df)
```

```
  t.test(stress_all~intervention, mu=0, conf=0.95, var.eq=F,
paired=F, data=week1_df)

  #Time must start at zero
  cleaned_df$week <- as.numeric(cleaned_df$week)
  cleaned_df <- mutate(cleaned_df, week = week - 1)

  #Percentatge of values missing
  pMiss <- function(x){sum(is.na(x))/length(x)*100}
  apply(dissdata,2,pMiss)
  apply(dissdata,1,pMiss)

  #WINSORIZING - outliers
  my_df$rec_loneliness_avg_win <-
Winsorize(my_df$rec_loneliness_avg)
  my_df$comm_orientation_all_win <-
Winsorize(my_df$comm_orientation_all)
  my_df$stress_all_win <- Winsorize(my_df$stress_all)
  my_df$social_activity_all_win <-
Winsorize(my_df$social_activity_all)

  #Filling Control Vars - again variables that were unlikely
to change over 4 weeks
  my_df <- fill(my_df, tech_experience, friends, staff,
                group_stranger, community_all,
relationship_status,
                romantic_partner_live, romantic_partner_care)
```

```
   ##### Indirect Effects MLM####
   write.csv(my_df, "dissdata_ready_for_bootstrap.csv")
   my_df <- read.csv("dissdata_ready_for_bootstrap.csv")
   ios_df <- subset(ios_df, sub_id != 'A4' & sub_id != 'B5' &
sub_id != 'F1')

   ios_df$intervention <- as.integer(ios_df$intervention)
   ios_df$week <- as.integer(ios_df$week)
   length(ios_df$sub_id)
   class(my_df$sub_id)
   class(ios_df$sub_id)
   new_df <- inner_join(x = my_df, y = ios_df, by =
c('sub_id', 'intervention', 'week'))
   class(new_df)
   head(new_df)
   new_df <- as.numeric(as.character(new_df))

   dissdata$IoSMara
   #Filling in missing data (this is for variables that were
only measured once but will not change)
   library(tidyr)
   dissdata %>%
     tidyr::complete(subid, Week)
   dissdata %>%
     tidyr::fill(VideoConsent)
   dissdata_fill <- dissdata %>%
```

```
    tidyr::fill(VideoConsent, Age, Sex, Ethnicity,
timeatMara,
                reasonforMara, familyclose, familytalk,
groupknowwell)
  dissdata <- dissdata_fill

  ######communal orientation####
  interaction.plot(x.factor = new_df$week,
                   trace.factor = new_df$intervention2,
                   response = new_df$comm_orientation_all,
                   fun = mean,
                   type = 'l',
                   trace.label = 'Intervention',
                   xlab = 'Week',
                   ylab = 'Communal Orientation',
                   col = c('blue2', 'red2')
                   )

  intervention2 = as.numeric(my_df$intervention2)
  Plot.co<-ggplot(data=my_df, aes(x=week,
y=comm_orientation_all_centered, group=intervention2))+
    geom_line(size=2, aes(color=intervention2))+
    ylim(0,4)+
    ylab("Communal Orientation")+
    xlab("Week")+
    ggtitle("Communal Orientation Over 4 Week \nVirtual
Reality Intervention")
```

```
Plot.co


####vitality#####
output_vit <- boot(data = my_df,
                   statistic = indirect.mlm,
                   R = 5000,
                   x = 'intervention',
                   y = 'vitality',
                   mediator = 'comm_orientation_all_win',
                   group.id = 'sub_id',
                   covariates = c('week',
                                  'group_know',
                                  'family_close',
                                  'time_at_mara',
                                  'group_stranger',
                                  'family_talk',
                                  'romantic_partner_care',
                                  'marital_status'),
                   strata = my_df$sub_id,
                   uncentered.x = F,
                   between.m = F)

indirect.mlm.summary(output_vit)

plot(output_vit)
```

```
  my_df$intervention2 <- factor(x = my_df$intervention,
labels = c("TV", "VR"))

  interaction.plot(x.factor = my_df$week,
                   trace.factor = my_df$intervention2,
                   response = my_df$vitality,
                   fun = mean,
                   type = 'l',
                   trace.label = 'Intervention',
                   xlab = 'Week',
                   ylab = 'Vitality',
                   col = c('blue2', 'red2')
  )

  #####stress####
  output_stress <- boot(data = my_df,
                    statistic = indirect.mlm,
                    R = 5000,
                    x = 'intervention',
                    y = 'stress_all_win',
                    mediator = 'comm_orientation_all_win',
                    group.id = 'sub_id',
                    covariates = c('week',
                                   'group_know',
                                   'family_close',
                                   'time_at_mara',
                                   'group_stranger',
```

```
                                    'family_talk',
                                    'romantic_partner_care',
                                    'marital_status'),
                    strata = my_df$sub_id,
                    uncentered.x = F,
                    between.m = F)

indirect.mlm.summary(output_stress)

plot(output_stress)

interaction.plot(x.factor = my_df$week,
                 trace.factor = my_df$intervention2,
                 response = my_df$stress_all_win,
                 fun = mean,
                 type = 'l',
                 trace.label = 'Intervention',
                 xlab = 'Week',
                 ylab = 'Stress',
                 col = c('blue2', 'red2')
)

####depression#####
output_dep <- boot(data = my_df,
                   statistic = indirect.mlm,
                   R = 5000,
                   x = 'intervention',
```

```
                    y = 'log_depression',
                    mediator = 'comm_orientation_all_win',
                    group.id = 'sub_id',
                    covariates = c('week',
                                   'group_know',
                                   'family_close',
                                   'time_at_mara',
                                   'group_stranger',
                                   'family_talk',
                                   'romantic_partner_care',
                                   'marital_status'),
                    strata = my_df$sub_id,
                    uncentered.x = F,
                    between.m = F)

  indirect.mlm.summary(output_dep)
  plot(output_dep)

  my_df$intervention2 <- factor(x = my_df$intervention,
labels = c("TV", "VR"))

  interaction.plot(x.factor = my_df$week,
                   trace.factor = my_df$intervention2,
                   response = my_df$log_depression,
                   fun = mean,
                   type = 'l',
                   trace.label = 'Intervention',
```

```
                  xlab = 'Week',
                  ylab = 'Depression',
                  col = c('blue2', 'red2')
)
####loneliness#####
output_lon <- boot(data = my_df,
                   statistic = indirect.mlm,
                   R = 5000,
                   x = 'intervention',
                   y = 'social_activity_all_win',
                   mediator = 'comm_orientation_all_win',
                   group.id = 'sub_id',
                   covariates = c('week',
                                  'group_know',
                                  'family_close',
                                  'time_at_mara',
                                  'group_stranger',
                                  'family_talk',
                                  'romantic_partner_care',
                                  'marital_status'),
                   strata = my_df$sub_id,
                   uncentered.x = F,
                   between.m = F)

indirect.mlm.summary(output_lon)
plot(output_lon)
```

```
  my_df$intervention2 <- factor(x = my_df$intervention,
labels = c("TV", "VR"))

  interaction.plot(x.factor = my_df$week,
                   trace.factor = my_df$intervention2,
                   response = my_df$rec_loneliness_avg_win,
                   fun = mean,
                   type = 'l',
                   trace.label = 'Intervention',
                   xlab = 'Week',
                   ylab = 'Loneliness',
                   col = c('blue2', 'red2')
  )
  ####social activity#####
  class(my_df['comm_orientation_all_centered'][1,])
  my_df$social_activity_all_win
  output_sa <- boot(data = my_df,
                    statistic = indirect.mlm,
                    R = 5000,
                    x = 'intervention',
                    y = 'social_activity_all_win',
                    mediator = 'comm_orientation_all_win',
                    group.id = 'sub_id',
                   covariates = c('week',
                                  'group_know',
                                  'family_close',
                                  'time_at_mara',
```

```
                                    'group_stranger',
                                    'family_talk',
                                    'romantic_partner_care',
                                    'marital_status'),
                    strata = my_df$sub_id,
                    uncentered.x = F,
                    between.m = F)
indirect.mlm.summary(output_sa)

plot(output_sa)

interaction.plot(x.factor = my_df$week,
                 trace.factor = my_df$intervention2,
                 response = my_df$social_activity_all_win,
                 fun = mean,
                 type = 'l',
                 trace.label = 'Intervention',
                 xlab = 'Week',
                 ylab = 'Social Activity',
                 col = c('blue2', 'red2')
)
```