Flattening the Curve, Mindfully -- Can Meditation Apps Help to Mitigate the Psychological Impacts of Social Distancing Measures during COVID-19?

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Abstract
The present study is an inquiry into the question whether meditation apps can mitigate some of the adverse psychological impacts that individuals commonly experience during pandemics. In a randomized controlled trial, subjects either practice meditation via Headspace or cognitive training via Lumosity for one week. Thereafter, the two groups are compared on loneliness and anxiety levels. The evidence of the results in this study suggest that a week of mindfulness training through a meditation app is not sufficient to have a significant impact on a person's psyche.

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Introduction

At the time of writing, the novel Coronavirus (COVID-19) pandemic was in full swing, rapidly spreading across the entire globe. Researchers warn that as the world population and interconnectedness between nations increases further, so will outbreaks of viral diseases (Smith, et al., 2014), meaning that we may be facing a future where pandemics are a lot more frequent than they were in the past. To still be able to thrive in this future, we need to do our best to learn from past and current outbreaks, and how to best manage them.

 In order to slow down the rate of infections of COVID-19 and not overwhelm their healthcare systems, governments in affected countries have been imposing public health measures such as social distancing, quarantine and self-isolation, thus purposefully limiting frequency and proximity of physical contact between people to varying degrees. The immediate importance of these measures is beyond any doubt if the spread of the coronavirus is to be contained but needs to be weighed against another factor concerning public well-being: mental health. So far governments have not been addressing the issue of how to manage mental health risks associated with measures to contain viral spread, despite evidence from previous epidemics: Hawryluck et. al (2004) show that, following the SARS (Severe Acute Respiratory Syndrome) outbreak in Canada, which was successfully contained by similar measures, a large number of quarantined individuals showed symptoms of PTSD (Post-traumatic Stress Disorder) and depression, amongst other psychological ailments; at the beginning of the present pandemic, researchers in China (where COVID-19 first emerged) surveyed affected individuals to assess the psychological impact that the spread of the disease and the resulting social distancing measures are having: across all 194 surveyed cities people consistently reported anxiety, depressive symptoms and excessive stress levels (Wang, et al., 2020).

For current and future management of viral disease outbreaks to be as efficient as possible, governments and policymakers need to consider the reported negative-side effects of social distancing and, when possible, use evidence-based measures on how to mitigate these effects to guide the public through the crisis. While evidence of the psychological side-effects is abundant, scientifically backed-up ways to tackle it are scarce! Filling this gap in research is what I aim to do in the present study. In search of existing practices that could

help with the above-mentioned ailments, one that stood out was mindfulness—defined as awareness, cultivated by paying attention to present-moment experience (Kabat-Zinn, 2003). Amongst others, Smith, et al. (2011) and Hoffmann, Sawyer, Witt , & Oh (2010) show that mindfulness can successfully reduce the symptoms of PTSD, depression, anxiety and a range of other psychological ailments commonly arising as a result of social distancing. The effect of mindfulness on these diseases has been studied, though never in the context of epidemics.

Unfortunately, the circumstances surrounding Coronavirus and the necessity for people to stay at home as much as possible, greatly limits the ways in which mindfulness can be exercised—common ways of practicing involve group- or one-on-one sessions with spiritual teachers, or yoga. Since governments in countries where the Coronavirus has spread are banning activities which require people to gather, these options are not feasible for the time-being. Nevertheless, a very accessible, and in fact much less expensive, alternative does exist in mindfulness meditation mobile apps! Mindfulness apps have been shown to aid mental health in similar ways as more traditional mindfulness practices, for example by improving mood and reducing stress (Walsh, Saab, & Farb, 2019). Whether they also constitute improved well-being during social distancing is what the central research question of this study inquires:

Can mindfulness training via mobile apps improve mental well-being in quarantine, self-isolation or social distancing?

The research question will be answered by carrying out a randomized controlled trial where the effect of mindfulness on some of the psychological ailments that resulted from isolation during the coronavirus pandemic will be assessed. The experiment will be designed to test a set of hypotheses, which will be outlined in the theoretical framework. As previously mentioned, the negative effects of isolation and the positive effects of mindfulness are in abundance and due to a lack of time and financial resources, the scope of the present research does not permit to test most of these effects. Thus, the herein chosen psychological ailments will be the ones where the effect can be tested immediately and with simple materials: anxiety and loneliness resulting from isolation during the coronavirus pandemic.

If nothing is done to mitigate the effects that the current public health measures have on anxiety and loneliness, we are risking not only individual suffering in the short term, but also knock-on effects which might trouble individuals long after the epidemic has passed, by fostering overly cautious lifestyles (Wright, 2020). Reynolds, et al., (2007) corroborate this idea by showing that several participants in their study kept avoiding public places and social gatherings long after the SARS outbreak in Canada was contained. Therefore anxiety, loneliness (all other psychological ailments too) could become chronic and have severe impacts on mental- and physical health in the worst case scenario. Globally, the consequences of this could be devastating, since coronavirus requires a lot more people to isolate than SARS or previous epidemics and hence places more people under risk of developing chronic disease.

It is precisely because of this, that researchers need to direct resources not into finding the psychological effects of isolation in epidemics—those are already known—but to find evidence-based methods of mitigating them. The present study is a contribution to this domain of research and its results can help us all to take a more holistic approach to tackling viral disease outbreaks—which would involve governments not only slowing the spread of disease, but also guiding affected individuals through these difficult times as best as possible.

Theoretical Framework & Literature Review

In order to answer the proposed research question, several hypotheses will be formulated, using theory from related literature. To this end, mindfulness will first be comprehensively explained, as will the psychological impacts of social distancing addressed in this study. How the concepts are interlinked will be outlined subsequently, which will result in sufficient theoretical groundwork to formulate the hypotheses to be tested in this study.

1. Mindfulness

1.1 What is Mindfulness?

Mindfulness has been defined manifold, with most definitions differing marginally. Brown & Ryan (2003) define it as a state of consciousness in which attention is paid to one's moment-to-moment experience; moment-to-moment experience can include a range of phenomena like one's breath, thoughts, emotions, feelings, pain and more. Within the practice of mindfulness each of these things is simply accepted and observed in a non-judgmental fashion rather than reacted upon (Kabat-Zinn, 2003). Common ways of practicing and cultivating mindfulness include sitting meditation, body scan, yoga, tai-chi and qigong (Schure, Christopher , & Christopher, 2008). When exercised through these practices, mindfulness is initially considered a state, not a trait (Davis & Hayes, 2011) i.e. present-moment awareness requires a conscious effort and is not felt through prolonged periods of time beyond the practice. However, Kiken, Garland , Bluth, Palsson, & Gaylord, (2015) argue that through extensive practice the qualities that mindfulness practice cultivates will seep into the day-to-day life more and more often, thus slowly becoming a trait, rather than just a state.

Mindfulness was first conceptualized in ancient eastern tradition and takes a central role in the teachings of the Buddha (Hanh, 1999) where it is at the root of many of the core insights that constitute the purpose of Buddhism: elimination of individual suffering (Kabat-Zinn, 2003). It is perhaps this aspiration towards reduced suffering that sparked the relatively recently resurged interest in mindfulness, which is evident from the increase of RCTs in the field: from only one between 1995–1997, to 11 between 2004–2006, and finally 216 between 2013–2015 (Powell, 2018). Many of these RCTs produced intriguing results which evidenced the various benefits that mindfulness has on mental and physical health. The findings show promise for a new branch of medicine that uses the minds innate abilities to cure disease—mental and physical—thus providing a more autonomous way for healing.

1.2 Mindfulness apps

As the beneficial effects of mindfulness started to be backed by scientific findings, the practice got pulled out of esotericism and more and more into the mainstream. Mindfulness apps, a more accessible and cheaper alternative to face-to-face mindfulness training, play a

key role in bridging the gap between esotericism and mainstream even further (Mani, Kavanagh, Hides, & Stoyanov, 2015). Cavanagh, Strauss, Forder, & Jones (2014) discuss the potential benefits of wide-spread use of mindfulness and point out several benefits: training via apps gives spiritual teachers the opportunity to reach a much wider audience and furthermore reduces the geographical, financial and social barriers to conventional mindfulness training compared with face-to-face training alternatives. Furthermore, mindfulness apps show promise for health-improvement with recent findings showing similar benefits as conventional mindfulness practice in reducing stress (Carissoli , Villani , & Riva, 2015) and increasing subjective well-being (Howells, Ivtzan, & Eiroa-Orosa, 2016). Scrutiny, however, is still reasonable when choosing to learn being mindful via apps, since the techniques put forward in the thousands of different apps available differ in style and also in efficacy (Roquet & Sas, 2018).

2. Psychological Impacts of Coronavirus and Social Distancing Measures

Human are born inherently social—some researchers go as far as to argue that our social nature is what makes us conscious, or at least enables us to be the dominant species on this planet (Adolphs, 2003). Thus, it is reasonable to assume that being cut off from our peers for prolonged periods of time--be It through social distancing, self-isolation or quarantine—combined with the possibility of catching a potentially life-threatening disease during this period will have an impact on how we feel mentally. The above-stated public health measures aim to protect the public by preventing exposure to people who may have caught an infectious disease to varying degrees, based on the probability that they indeed are infected (Maragakis, 2020). Isolation separates people who are definitely sick from the public, quarantine does the same for people who are merely suspected or at increased risk to carry the infection and social distancing refers to general avoidance of face-to-face contact with other people (Maragakis, 2020).

Hawryluck, et al., (2004), Wang, et al., (2020) and (Brooks, et al., 2020) have shown that the effects on mental health can be far-reaching and affected individuals are being diagnosed with a wide range of mental illness: PTSD, confusion, anger, loneliness and anxiety, amongst many more stressors.

2.1 Anxiety (and Uncertainty)

An exact definition of anxiety is difficult to put forward, since it has been conceptualized in many ways. It is generally considered to be a cognitive-affective state with a pervading sense of inability to control a future threat or danger (Barlow, Chorpita, & Turovsky, 1996). States of anxiety are considered unpleasant and characterized by feelings of fear, tension, apprehension and worry, coupled with an activation of the automatic nervous system (Endler & Kocovski, 2001; Spielberger & Rickman, 1990). Spielberger & Rickman (1990) posit that preceding situations of real threat or danger anxiety is a 'normal' defense mechanism that aims to prepare a person for such threats. However this defense mechanism can get out of hand and activate when actual threat is minimal or disproportionately small relative to the intensity of anxiety. This is what characterises various so-called anxiety-disorders.

In the 21st century, Bandelow (2015) argues, anxiety-related mental disorders have become the most prevalent neurological ailment with 33.7% of the world population affected to varying degrees, resulting in immense healthcare expenses globally. In recent months this number has likely grown further due to the coronavirus.

Part of what makes this public health crisis and its preventive measures malicious to the psyche is the fact that it is shrouded in uncertainty. The likelihood of disease contraction and the depth of the economic recession, for instance, are near impossible to predict, while both hold the potential to deeply affect well-being. Uncertainty does not affect every person in the same way—indeed, people have varying levels of tolerance towards it (Dugas, Schwartz , & Francis, 2004). Dugas, Schwartz , & Francis (2004) furthermore define Intolerance of Uncertainty as a cognitive bias that affects how a person perceives, interprets, and responds to uncertain situations on a cognitive, emotional, and behavioral level; they also consider it the root cause of GAD (General Anxiety Disorder). More precisely, the psychological link between uncertainty and anxiety is the following one: when future outcomes are uncertain, people are less effective and efficient in preparing for the future, which results in feelings of anxiety (Grupe & Nitschke, 2013). Moreover, the possible future threats which an anxious mind is concerned with, tend to be ones which the person is not able to resolve (Borkovec, 2006), such as the previously outlines coronavirus-related threats.

2.2 Loneliness

Perhaps an even more obvious effect then anxiety that the present public health measures have on mental health is loneliness. Humans developed as an inherently social species (Adolphs, 2003) and loneliness, as a form of defense mechanism—"the social equivalent of physical pain, hunger and thirst" (Hawkley & Cacioppo , 2010)—signals to a person that he is lacking social contact. Not tending to this lack has been shown to severely damage the psyche and substantially increase mortality (Svendsen, 2017; Holt-Lunstad, Smith, Baker, Harria, & Stephenson, 2015).

Social distancing can severely reduce the amount of social contact a person is normally having; however, this is not exactly what is increasing loneliness—isolation and being lonely are not the same thing. While the former is simply the objective lack of contact itself, feelings of loneliness arise due to a *perceived* lack of social interaction, with individual needs of a certain amount of social contact as a reference point (Svendsen, 2017), thus being a subjective construct. This means that some people will experience isolation and social distancing with more severe feelings of loneliness than others. Some may argue that social use of the internet will reduce the negative effects of isolation on loneliness during this crisis, however results from research around this relationship are inconclusive. In fact, a substantial amount of studies argue that using the internet for social purposes increases loneliness, but most of this research is cross-sectional and is therefore ill-suited to establish cause-effect relationships (Nowland, Necka, & Cacioppo, 2018). There may be a difference between substituting face-to-face contact with social internet use as a choice and being forced to do so, however this remains largely unexplored and is beyond the scope of the present research.

3. Hypothesis Formulation

Uncertainties can make people feel anxious to varying degrees, depending on their intolerance of uncertainty levels (Dugas, Schwartz , & Francis, 2004). Moreover, people with a higher intolerance of uncertainty are more likely to feel anxious in the face of uncertain events. This should be no different with the uncertainties surrounding coronavirus but is nevertheless subject to be tested. Thus, the first hypothesis is:

H1: Individuals with higher intolerance of uncertainty experience higher levels of anxiety during the ongoing Coronavirus epidemic.

As previously mentioned, feelings of anxiety often arise due to the uncertainty of and pre-occupation with future events. Mindfulness practice, such as meditation, teaches people to openly and non-judgmentally pay attention to present-moment experience and thereby helps them to redirect attention away from past or future events and into the present moment, which can effectively counter feelings of anxiety (Kabat-Zinn, 2003). In contrast, mindlessness is an individual minds unconscious preoccupation with past and future events (Langer & Moldoveanu, 2002). Evans & Segerstrom (2010) identified that repetitive and future-concerned thoughts in uncertainty intolerant individuals, which cause them to feel anxious, can be mitigated through mindfulness practice—specifically, through the non-judgmental acceptance of ones thought patterns. More broad empirical evidence of this relationship between mindfulness and anxiety exist too: A meta-analysis by Goyal et. al (2014) show that across 4 trials with a total of 3515 participants, various meditation programs (8-week duration) had an average (negative) effect size of 0.38 on anxiety. Whether the same pattern holds true for anxiety related to coronavirus and social distancing, and if the effects can be mitigated with a meditation app is what forms the second hypothesis in the present research:

H2: Practicing mindfulness via mobile applications reduces anxiety in individuals practicing some form of social distancing during an epidemic.

Since feelings of loneliness arise due to a perceived lack of social interaction, measured against a baseline that a person thinks he needs or is used to having (Svendsen, 2017), the root of the problem lies in weighing past experiences against the present. As mindfulness practice is meant to center attention on the present-moment experience, with only non-judgmental and accepting considerations of the past, it can potentially reduce subjective loneliness. Indeed (Cresswell, et al., 2012), show that participants of the MBSR (Mindfulness-based stress reduction) program showed significantly larger reductions in subjective feelings of loneliness compared to a control group. Whether a similar effect can be achieved in the context of social distancing during an epidemic and having to practice mindfulness via a mobile app is assessed through our final hypothesis:

H3: Practicing mindfulness via mobile applications reduces loneliness in individuals practicing some form of social distancing during an epidemic.

Methodology

Data gathering was done collaboratively with Nathan Warren (Master's thesis student) at Erasmus School of Economics, also researching in the field of mindfulness and decision-making. For both researches the experimental design was the same, but the questions pertaining to the outcome variables differed.

To test the prior stated hypotheses an experiment with a randomized controlled trial was carried out. The proceedings are outlined below.

Experimental Design

The experiment entails testing the effect of using Headspace—a mindfulness meditation app—on loneliness and anxiety during social distancing against an active control group, using Lumosity—an app for the development of cognitive skills. The control group is subjected to a form of intervention, thus active control group, in order to control for participants effects of expectancy and daily engagement. A cognitive training app is chosen since it engages participants without increasing their levels of mindfulness. Eligibility criteria to take part in the experiment are as follows:

a) owning a smartphone and willing to try out a new app (for mindfulness training will be conducted via Headspace),
b) complying with social distancing measures (for the interest of the study is the mitigation of the ailments which social distancing brings forth)
c) not being clinically diagnosed with mental illness or taking medication against it (for either can significantly interfere with the variables of interest and the treatment condition).

Upon compliance with these criteria, participants are informed that they are invited to participate in an experiment that aids research surrounding the use of mobile applications during the corona-crisis. The exact aim of the experiment remains undisclosed for it could

induce an experimenter demand effect in participants' responses later on. Thereafter participants were familiarized with the terms and conditions of the experiment which entail the following:

- Using the assigned app at least once per day over a 7-day period
- Anonymously filling in a self-report survey before and after the 7-day period

Following approval of these conditions, subjects are randomly assigned to either the treatment- or the control group as well as given their unique 4-digit code to use as an ID to link the baseline and follow-up survey. Each participant is instructed to take a screenshot or write the code down somewhere in order to remember it after the treatment period. Identification via unique codes enables us to fully preserve the anonymity in subjects' responses.

Depending on which group they have been assigned to, participants are instructed to download either Headspace or Lumosity on their smartphone, subscribe to the 14-day free trial in either app and use it at least once daily for 7 days. The duration of daily engagement is left up to each subject to decide on. Along with these instructions participants receive a questionnaire for basic demographic variables and various control variables. The demographic variables are age, gender, country of residence, occupation and highest level of education. The control variables are prior experience with mindfulness training, prior experience with meditation apps prior experience with cognitive training apps, trait mindfulness for it has a positive effect on state mindfulness (Kiken, Garland , Bluth, Palsson, & Gaylord, 2015), trait anxiety for it has a positive effect on state anxiety (Lau, Eley, & Stevenson, 2006), number of cohabitants for it impacts the amount of social interactions and hence also subjective feelings of loneliness; and social belongingness for it predicts lower loneliness (Jose & Lim, 2014). At the end of the 7-day experimental period (t=1), the second questionnaire is sent out with self-report questions to measure the outcome variables: state-mindfulness, state-anxiety, loneliness and intolerance of uncertainty. Demographic- and control variables are excluded at t=1. App-adherence was also measured at t=1 through a self-report question, asking respondents on how many days they actually used the app. It was initially planned to measure app adherence by asking subjects to share a screenshot from within the Apps usage tracker. By the time the second survey was sent, this turned out to not

be feasible, as EUR's Qualtrics subscription did not have the 'file upload' function enabled.

For the readers convenience, the entire RCT is summarized visually in Figure 1.

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│ Email Invitation to participate │
│ with survey link            │
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              ▼
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│ Eligibility criteria        │
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┌─────────────────────────────┐
│ Terms & Conditions          │
└─────────────────────────────┘
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Treatment Group Allocation
Instruction: Use meditation app Headspace for 7 days, daily.

Control Group Allocation
Instruction: Use cognitive training app Lumosity for 7 days, daily.

T=0 Measurements
- Demographics
- Experience with mindfulness
- Experience with meditation apps
- Trait mindfulness
- Trait Anxiety
- Social belongingness

T=0 Measurements
- Demographics
- Experience with mindfulness
- Experience with cognitive training apps
- Trait mindfulness
- Trait Anxiety
- Social belongingness

T=1 Measurements
- State mindfulness
- State anxiety
- Loneliness
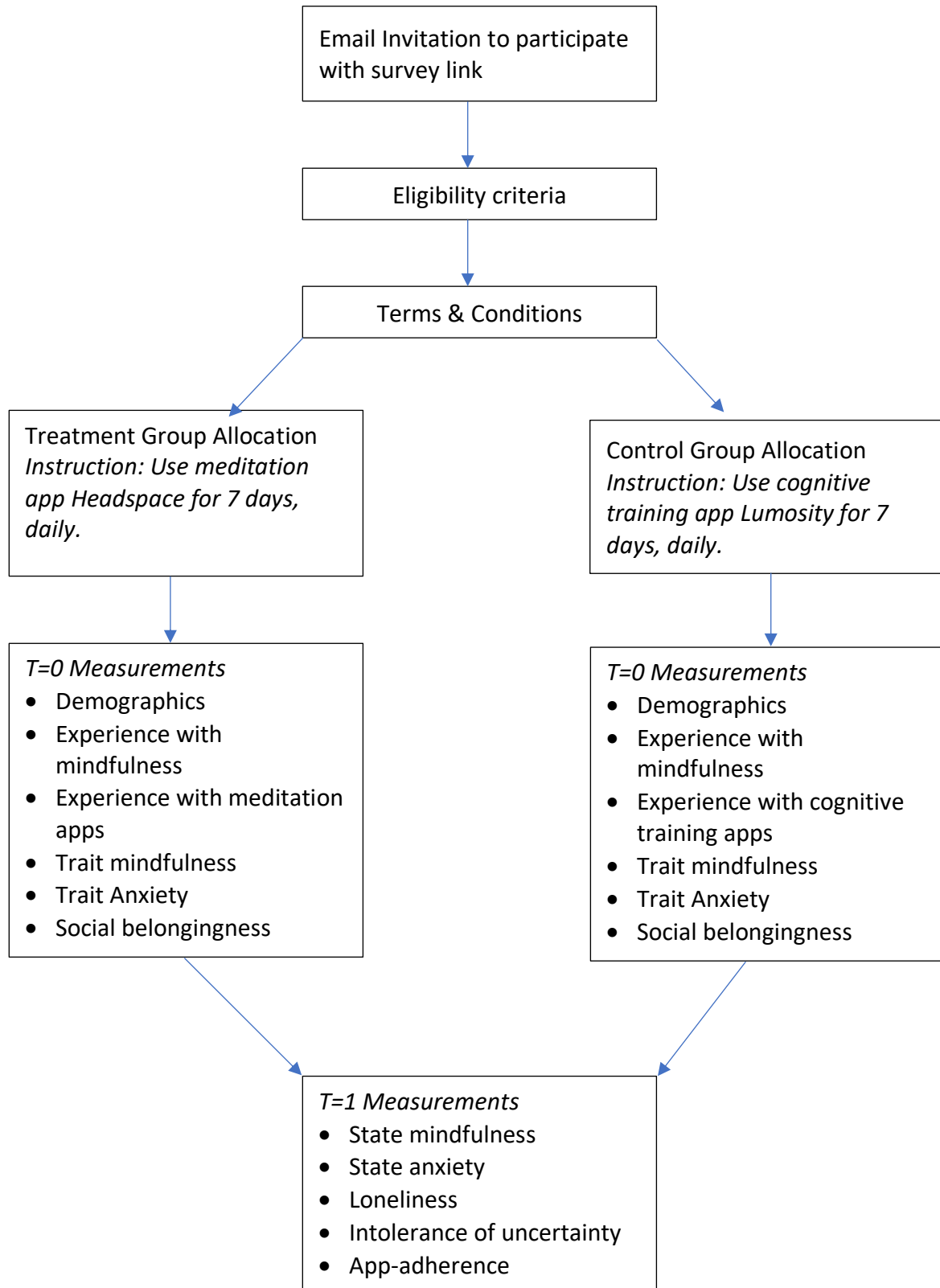- Intolerance of uncertainty
- App-adherence

Figure 1: RCT structure

Compared to most clinical RCTs on the effects of mindfulness on various psychological constructs, no pre- vs. post treatment effects on dependent variables within groups are assessed—the relatively short experimental period of 7 days could lead subjects to anchor responses at t=1 to responses at t=0.

Regression models and hypothesis testing

The effect of mindfulness on loneliness and anxiety is assessed using multiple regression models. Prior to examining those models, randomization checks are employed to ensure that the treatment and control group do not differ significantly. Given that at least one of the conditions of normality, equal variance and measurement of variables in interval scales will not be satisfied for each variable, non-parametric tests are employed to this end. Specifically, Fisher-Exact and Mann-Whitney U tests are used on the main demographic variables as well as control variables which can influence state-mindfulness, state-anxiety or loneliness and the relationships between these variables. Those variables which are ordinal will be checked using the Fisher-Exact test, and those which are nominal will be checked using the Mann-Whitney U test. As a manipulation check, to see if using Headspace for 7 days has an impact on subjects, state-mindfulness at treatment-level (t=1) is compared between treatment and control groups, either also by means of a Mann-Whitney U test or, incase the distribution of the state-mindfulness variable is normal, a t-test (with unequal variance assumption). The expectation is that the treatment group has higher levels of state-mindfulness at t=1 compared with the control group.

In order to test the 1st hypothesis (H1: Individuals with higher intolerance of uncertainty experience higher levels of anxiety during the Coronavirus epidemic) a regression model is set up with state-anxiety as the dependent variable and intolerance of uncertainty as the explanatory variable. A positive relationship between intolerance of uncertainty and state-anxiety is expected.

The two regressions models which aim to test hypotheses 2 and 3 (H2: Individuals subject to some form of social distancing, practicing mindfulness via an app experience less anxiety, compared to an active control group; H3: Individuals subject to some form of social distancing, practicing mindfulness via an app experience less loneliness, compared to an active control group.) have state-anxiety and subjective loneliness as dependent variables. Both regressions include a dummy variable for the group (control group or treatment group;

the dummy is coded 1 for the treatment group, while the active control group serves as the reference category) as a regressor to see using Headspace versus Lumosity has an effect on anxiety and loneliness. Should there be significant differences between the groups in any of the control variables, then those are included in the regression to assess the relationship when they are held constant. I expect that the use of Headspace relative to the use of Lumosity will have a positive effect on state-anxiety and subjective loneliness (by positive effect is meant that state-anxiety and loneliness are reduced). The regressions are estimated using OLS.

Regression analysis is performed using STATA. The scales used to measure the above-mentioned variables are outlined in the following sub-section.

Scales and measurement of variables

The following scales are used to quantify the dependent variables as well as some of the control variables used in the regression models:

1. *IUS (Intolerance of Uncertainty Scale)* (Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994) includes 27 items which aim to assess the respondent's perceptions and psychological responses to uncertainty. The questionnaire poses statements and asks the respondent to indicate on a 5-point Likert scale how much he can identify with each statement. Higher scores correspond to high intolerance of uncertainty. The scale has high internal consistency with Cronbachs-alpha of 0.91.

2. *STAI (State-Trait Anxiety Inventory)* (Spielberger C. , 2010) is a commonly used self-report measure of anxiety to assess respondents state-anxiety (dependent variable) and trait-anxiety (control variable). The former refers to measures momentary anxiety related to a certain event or circumstance, while the latter is a person's predisposition to be anxious. The STAI is a 4-point Likert scale with 40 statements in total—20 to assess each type of anxiety. High scores on the STAI positively correlate with anxiety. Low scores indicate light, almost negligible anxiety, whereas median scores indicate moderate anxiety, while high scores indicate severe anxiety. The scale has a Cronbach-alpha coefficient of 0.86, therefore has high internal consistency (Quek et. al, 2004).

3. *UCLA Loneliness Scale* (Russel, 2010) is a 20-item self-report measure of subjective loneliness and feeling of social isolation. It is scored on a 4-point Likert scale and higher

overall scores are associated with higher levels of loneliness. According to Russel (1996) the measure has a high internal validity with Cronbach-alpha coefficients ranging from 0.89 to 0.94.

4. *PHLMS (Philadelphia Mindfulness Scale)* (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008) is a 20-item self-report measure of state-mindfulness with items scored on a 5-point Likert scale. The PHLMS has two sub-scales for measuring two components of state-mindfulness: acceptance and awareness. The CAMS shows adequate internal consistency with Cronbachs-alpha of 0.85 and 0.87 for the awareness- and acceptance sub-scales, respectively (Cardaciotto et. al, 2008). High scores indicate high levels of state-mindfulness

5. MAAS (Mindfulness and Awareness Scale) (Brown & Ryan, 2003) is a 15-item self-report measure of trait-mindfulness i.e mindfulness as a personal characteristic with a 6-point Likert scale. With a Cronbachs-alpha of 0.82 (Brown & Ryan, 2003) the scale has good internal consistency. High scores indicate high levels of trait-mindfulness.

6. *The Social Connectedness and Social Assurance Scales* (Lee & Robbins, Measuring belongingness: The Social Connectedness and the Social Assurance scales., 1995) are commonly administered together with the goal of measuring a respondents' feeling of social belonging. Together they contain 12 self-report items which are scored on a 5-point Likert scale. Internal consistency estimates for the 2 scales were .91 and .82, respectively (Lee & Robbins, 1995).

Recruitment

Recruitment for the experiment is carried out using the snowball sampling technique via social media channels of both experimenters. The control- and treatment group conditions are identical for both experiments and questions of both researchers are combined in the surveys. To ensure that respondents endurance in completing the surveys is equally distributed between both experimenters question, the order of the questions is mixed up. A power calculation to determine an appropriate sample size did not seem feasible for this study, given that the effect of mindfulness on loneliness has not been sufficiently studied and the effect of mindfulness on anxiety has so far only been tested in clinical trials which involve the following complications from our point of view:

- Participants in clinical experiments largely have various forms of anxiety disorders putting them above an average level of anxiety, which is not expected from participants in this study.
- Treatment effects are often established from pre- to post treatment levels, which, given the length of the experimental period, is not feasible

Apps

1. *Headspace* (Treatment group app) provides guided meditations online or via a mobile app. The mediations, which mostly range from 5-20 minutes, are guided by Andy Puddicombe, the founder of the company and former buddhist monk. The content of the meditations is inspired by concepts of mindfulness and the blog on the website offers educational posts about the health benefits of meditation practice and the science that backs these claims. With a score of 4.0 Headspace had the highest MARS (Mobile Application Rating Scale) of all mindfulness applications in the Apple App Store, based on engagement, functionality, visual aesthetics, information quality and subjective quality sub-scales (Mani, Kavanagh, Hides, & Stoyanov, 2015).

2. *Lumosity* (Active control group app) is a cognitive training app, designed to improve communication, analytical skills and memory power through playing games. Lumosity has a similarly high MARS as Headspace amounting to 4.7 and conveniently also offers a 14-day free trial like Headspace.

Results

Sample

The initial survey was filled out by 55 people, of which two did not agree to our terms and conditions and 12 turned out to be ineligible to participate in the experiment (due to either not following social distancing measures, being diagnosed with mental illness or not willing to try out a new mobile app). From the 41 remaining participants one lost the unique ID given during the first survey, thus could not respond to the questions on the second survey. Finally, 16 of the respondents were lost due to attrition i.e. did not respond on the 2nd survey,

following several reminders via email. So, the resulting dataset contained 24 respondents with a full range of responses on all questions from both surveys. Of these 24 respondents 11 belonged to the control group and 13 belonged to the treatment group. In Figure 1, the composition of the sample is summarized
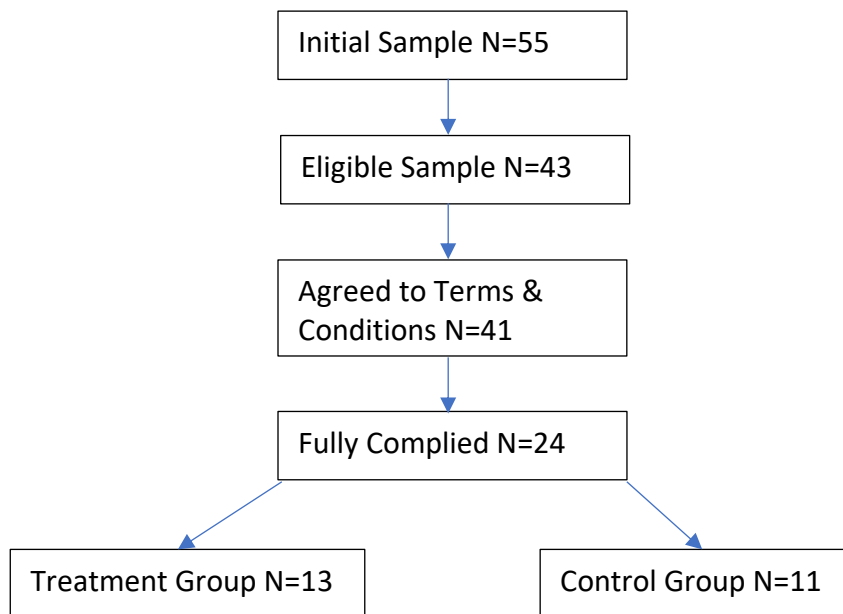
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                    ┌─────────────────────────┐
                    │   Initial Sample N=55   │
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                    │  Eligible Sample N=43   │
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                    │    Agreed to Terms &    │
                    │    Conditions N=41      │
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                    │   Fully Complied N=24   │
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        │ Treatment Group N=13 │   │  Control Group N=11  │
        └──────────────────────┘   └──────────────────────┘
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Figure 2: Sample Composition; Fully Complied includes everyone who successfuclly returned the 2nd survey

Descriptive statistics at baseline (t=0)

Most of the 24 respondents were students, with 62.9% falling in this occupational category. The rest were in full-time or freelance employment and one respondent had an unspecified occupation. Since the sample was gathered through social media channels of the experimenters, it is presumable that respondents who are employed completed their education fairly recently. This also reflects in the mean age of the sample: 23.4 years. Furthermore, the experimenter's social media reach was mainly spread across the Netherlands and Australia, which also reflects in the sample: 79% of all respondents came from either of the two countries. Predominantly, the respondents were men with 15 males and 9 females in the sample. Contained in the survey were also control variables directly related to the variables of interest in this study. Part of this was asking whether respondents have had previous experience with mindfulness training to which 16 responded positively. Of those 16 respondents, the average amount of days that a mindfulness practice was carried out was 3.25 days. It must be noted that the intensity and seriousness of the respondent's

prior involvement with mindfulness practice remained unobserved. For treatment and control group, respondents were asked whether they had previous experience with meditation apps and cognitive training apps respectively. The results showed 7 having previous experience with the former, and 1 with the latter. Subjects were also asked for how many cohabitants they presently live with -- the responses yielded an average of 2 cohabitants -- an unsurprising result given that most respondents were students. Various psychological constructs were also measured at t=0 to be used as control variables. These included trait anxiety, trait mindfulness and social belongingness. Mean scores (Standard Deviation) across the sample on these constructs were 45.7 (11.5), 55.5 (9.08) and 67.1 (11.38) respectively. Trait anxiety in our sample is slightly more than what Spielberger (2010) considers a 'high level'; the cut-off point named by him is 40. Trait mindfulness in our sample is close to the 57.75 that Brown & Ryan (2003) found in their undergraduate student sample. Lee, Draper, & Lee (2001) had a slightly younger sample at 19.5 years on average with a substantially higher mean Social Belongingness score at 88—subjects in our study showed lower levels of social connectedness. According to the subjects self-report, app-adherence was good with an average of 6.4 days across the sample. The survey was closed 2 days after the end of the 7-day experimental period, because several subjects needed multiple reminders to fill in the 2nd survey. Thus, some subjects have used the app beyond what was required: up to 9 days. The above-mentioned descriptive statistics are summarised and separately given for control- and treatment group in Supplemental Table 1, to be found in the Appendix.

Randomisation check

To see whether some of the control variables need to be added to the final regression models, randomisation checks on the control variables were performed using Fisher-Exact and Mann-Whitney U tests for nominal and ordinal/scale variables respectively. The differences between the groups on all control variables and the test statistics of these differences can be seen in Supplemental Table 1. No significant differences on any of the control variables ($p \geq 0.257$ for all differences) were found, meaning that randomisation was successful and the treatment did not significantly differ from the control group at baseline measurement (t=0).

Manipulation check

To answer the research question, three hypotheses were put forward, with each focusing on one of three outcome variables: Intolerance of uncertainty, state anxiety and loneliness. The latter two variables were hypothesised to be negatively affected by an increased state mindfulness within the treatment group as a result of daily meditation through Headspace. Table 1 summarises the measurements of state mindfulness, the three outcome variables and the extent to which subjects have used the app during the 7-day experimental period.

	Overall (N=24)		Treatment Group (N=13)		Control Group (N=11)		Difference (P-Value)
	Mean	SD	Mean	SD	Mean	SD	
State Mindfulness	67.17	10.66	64.23	8.43	70.64	12.31	-6.41 (0.162)
Intolerance of Uncertainty	56.92	16.70	57.23	14.30	56.55	19.90	0.68 (0.925)
State Anxiety	38.67	8.53	39.85	7.57	37.27	9.74	2.58 (0.485)
Loneliness	39.2	7.20	40.15	5.32	38.10	9.10	2.05 (0.)
App-Adherence (in days)	6.42	1.64	6.08	1.93	6.82	1.17	-0.74 (0.517)
Table 1: Summary of outcome variables							

The distributions of all outcome variables, except App-Adherence in Table 1 turned out to not significantly differ from normal (Appendix; Supplemental Table 2). Hence the difference in means between treatment and control group were tested using t-test for State Mindfulness, IUS, State Anxiety and Loneliness. Unequal variances were assumed for the t-tests. A Mann-Whitney U test was employed to check whether the difference in group means significantly differed in App-adherence since the normality condition for a parametric test was not satisfied. Hence, even if the treatment did produce an effect, it was not reflected in the state mindfulness scores at t=1 as the control group showed higher scores and the difference was not statistically significant. The differences between groups and the test-

statistics of either the t-tests or the Mann-Whitney U test incase for app-adherence are summarised in the last column of Table 1. The observations presented in Table 1 did not seem to be a result of differing app-adherence between the groups—it can also be seen in Table 1 that the usage of the app was slightly higher in the control group but not significantly so.

Hypothesis testing

The failed treatment reflects in the scores of state anxiety and loneliness, which, against my expectation, were lower in the control group compared to the treatment group. The t-tests on the difference in means of loneliness and anxiety between the two groups, did not show a significant difference as seen in Table 1. Furthermore, intolerance of uncertainty turned out to be higher in the treatment group compared with the control group, this result also being statistically insignificant. That is independent of the treatment however

Within the scope of this study, the failed manipulation check suffices as evidence that doing one week of mindfulness training using Headspace compared to using Lumosity for cognitive training does not reduce anxiety or loneliness. Thus, the 2nd and 3rd hypotheses are rejected. Nevertheless a series of regressions were performed to test the 1st hypothesis (*H1: Individuals with higher intolerance of uncertainty experience higher levels of anxiety during the ongoing Coronavirus epidemic.*). In Table 2, Model 1 we can see that Intolerance of Unceratainty was positively associated with State Anxiety, significant at the 5% level. Since the highest possible score is larger in the Intolerance of uncertainty scale compared with the STAI state-anxiety subscale (135 vs. 80), a 1-point increase on the IUS will produce a proportionately smaller effect than 0.252-point increase on the STAI. We can conclude that there is a moderately strong positive effect, and we therefore fail to reject the 1st hypothesis of this study.

	(Model 1)	(Model 2)	(Model 3)
	State Anxiety	State Anxiety	Loneliness
Intolerance of Uncertainty	0.252** (0.105)		
State Mindfulness		0.32** (0.150)	0.03 (0.111)
R^2	0.24	0.16	0.00

N	24	24	24

*Significant at 10%; **Significant at 5%;***Significant at 1%; SD in parentheses

Table 2: OLS Fixed effects regression model

Additional results

Even though state mindfulness was not manipulated by the treatment in this study, the relationship it has to anxiety and loneliness is worth exploring across the entire sample. The results of this can be seen in Models 2 and 3 in Table 2.) For this analysis the expectation was still that state mindfulness is associated with reducing state anxiety and loneliness.

Contrary to what was expected, state mindfulness actually had a positive relationship to state anxiety (across the entire sample), meaning more mindful individuals showed higher levels of anxiety. This effect was significant at the 5% level and is moderately large at 0.318. The range of scores between the STAI and PHMS is similar, so in proportion a 1-point increase in state mindfulness produces a slightly larger increase in state anxiety. Lastly, state mindfulness showed a positive effect on Loneliness across the whole sample, however the effect was neither statistically, nor economically significant at 0.026

Discussion

Resulting from the prior analysis, all but the first hypotheses were rejected. Accepting the first hypotheses leads me to believe that individuals with higher intolerances of uncertainty are likely to feel more anxious during epidemics. This result was expected, since the link between uncertainty and anxiety is well documented in the academic literature and epidemics, such as the current COVID-19 crisis, introduce uncertainty into numerous spheres of most people's lives. To be able to more accurately ascribe this effect to the current public health affairs however, panel data from the subjects of the study should have been collected. By measuring the differences in state anxiety in 'normal' times against the current epidemic, it would become apparent how much the crisis really impacts people's anxiety levels. Unless this is done, whether COVID-19 really makes people significantly more anxious or not, or whether it is an unobserved factor that is causing a rise in anxiety, remains an assumption.

Primarily, the second hypothesis had to be rejected, since the intervention did not work, as shown by the negative manipulation check (the treatment group and control group did not significantly differ on scores of state mindfulness), which may have several reasons. On one hand, the absence of tangible incentives (due to limited resources) meant that participants intrinsic motivation would determine the seriousness of engagement with the experiment. This internal motivation may not have been sufficient in our sample to bring about differences in mindfulness levels—this is also reflected in the substantial attrition in the sample. On the other hand, however, it is not clear how financial incentives would have changed subjects' engagement with mindfulness practice—something worth exploring in future research—and would in any case be difficult to monitor, since the experiment had to take place at a distance (due to social distancing measures). It may also make sense to look to the length of the experimental period as the reason for the failed intervention—in fact, the experimental period in this study (7 days) is relatively short compared with other RCT on mindfulness training, such as the ones previously cited in this paper for example, and may not have been long enough to trigger a significant change in mindfulness. However, even the mere extension of the experimental period may not be enough to significantly improve the effectiveness of the treatment—subjects may also have lacked the necessary education and training to practice mindfulness in an appropriate way. This could largely be a product of how mindfulness and meditation are advertised in the modern world. In various mainstream news articles and magazines mindfulness and meditation are portrayed as a shortcut alleviation of stress, anxiety, depression, etc… without further explanation of how to practice it. Evans & Segerstrom (2010) explain that at the root of mediation practice lies non-judgmental acceptance of one's emotions and psychological ailments. In other words: the goal of the meditator should never be the removal of a certain psychological ailment but rather the accepting it simply letting it be without becoming emotionally attached to it. Wolitzky-Taylor, Horowitz, Powers, & Telch (2008) corroborate this idea by meta-analytically finding that the most effective method of dealing with psychological stressors is not suppressing them or actively trying to make them go away, but willingness to be curious about and open to them.

Using mediation practice with the wrong intention or goal could also explain the surprising effect found in Model 2 in Table 2: Across the whole sample higher state mindfulness was associated with higher state anxiety i.e. more mindful individuals experienced anxiety more accutely. Birtwell, Williams, van Marwijk, Armitage , & Sheffield

(2019) find that one thing many novices to mediation practice find difficult to grasp, which in some cases can lead to adverse outcomes, is the absence of an ultimate goal in meditation practice. Commonly, a goal that people saw was alleviation from their ailments—this is considered denial of the present moment and therefore misses the point of formal meditation practice.

The primary reason for rejecting the 3rd hypothesis, as well as the 2nd, stems from the fact that the intervention in this experiment was unsuccessful (possible reasons were previously explained). However, over the entire sample state mindfulness also showed no significant effect on loneliness i.e. more mindful individuals were not on average less lonely than less mindful individuls. On one hand, this could be explained by our sample scoring low on social belongingness, thus subjectively not experiencing a significant change in their how socially active they are in social distancing compared to their 'normal' life. On the other hand, subjects could have simply not followed the public health guidelines as prescribed by their governments. A criterion for respondents to the first survey to be included in the sample was whetehr they were adhering to the public health-measures—whether they actually did, or whether they understood all public health measures correctly remained unobserved.

Also worthy of consideration, and applicable to all hypotheses tested in this research, is the relatively small sample size of this RCT. Having a larger sample with a higher variance some of the demographic variables may have poroduced different results for several reasons. Our sample largely cosnisted of young adults who are either full-time students or have just entered employment. This is a group, generally less at risk of being lonely or anxious, when compared with elderly, for example.

Conclusion and Final Remarks

The aim of this study was to find out whether mental health ailments resulting from the public health measures necessitated by the spread of COVID-19 could be mitigated through practicing mindfulness meditation via a mobile application. Two of the hypotheses put forward to answer the research question were rejected, thus the evidence in this paper is not sufficient to confirm meditation apps as a shortcut method to reduce anxiety and loneliness via increased mindfulness. The herein presented findings show that, at least if used over a short period of time (7 days), using Headspace neither improves levels of state

mindfulness, nor reduces loneliness and anxiety. This evidence, however, is not exhaustive. Several limitations of the present research methodology were outlined in the previous sub-section and can serve as guideline for future research--most notably the experimental period was relatively short, incentives and monitoring of the subject were absent and the sample size was relatively small and not very varied.

The fact still remains that leaders in the government across the globe are not yet equipped to efficiently deal with the threats that epidemics pose to the psyche. Thus, my recommendation is not to prematurely jump to conclusions about the ineffectiveness of meditation apps. Future research equipped with more resources and time could uncover ways in which meditation apps can help people handle a crisis of this nature better.

Appendix

Outcome	Overall (N = 24)				Control (N = 11)				Treatment (N = 13)				Difference	
	Mean (N)	SD (%)	Min	Max	Mean (N)	SD (%)	Min	Max	Mean (N)	SD (%)	Min	Max	Mean	P-Value
Gender (% male)	15	62.5	0	1	6	54.6			9	69.2			-14.6%	0.675
Residence (% NL + AUS)	19	79.2	0	6	8	72.7			11	84.6			-11.9%	0.809
Occupation (% Student)	15	62.5	0	4	7	63.6			8	61.5			2.1%	1.000
Mindfulness Exp. (% 'Yes')	16	66.7	0	1	6	54.6			10	76.9			-22.3%	0.257
App Experience (% Have Exp.)	8	33.3	0	1	1	8.3			7	58.3			-50%	0.257
Mindfulness Practice Frequ. (days p week)	3.3	1.53	1	6	3.3	1.51	2	5	3.2	1.62	1	5	0.1	0.822
Age	23.4	2.38	19	29	23.7	2.69	21	29	23.2	2.15	19	28	0.5	0.929
Cohabitants	2	1.22	0	5	1.9	1.14	0	4	2.1	1.32	0	5	-0.2	0.811
App-adherence (days)	6.4	1.64	2	9	6.8	1.17	4	9	6.1	1.93	2	9	0.7	0.301
Trait Anxiety	45.7	11.5	22	69	46.4	14.94	22	69	45.2	8.26	34	58	1.2	0.622

Trait Mindfulness	55.5	9.08	43	77	55.1	11.82	43	77	55.9	6.44	46	71	-0.8	0.416
Social Belongingness	67.1	11.38	42	88	64.9	12.37	42	80	69	10.59	49	88	-4.1	0.582

Supplemental Table 1: Descriptive statistics for the demographic and control variables; SD=Standard Deviation; for categorical variable, the number (N) and percentage of a certain category (%) are given instead of the mean and SD; Differences are tested for significance using the Mann-Whitney U test and Fisher-Exact test.

	Shapiro-Wilk P-Value
State Mindfulness	0.667
Loneliness	0.746
State-Anxiety	0.528
Intolerance of Uncertainty	0.506
App-Adherence	0.059
Supplemental Table 2: Shapiro Wilk test for normality of distribution of outcome variables.	

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