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**Examining Cigarette and Craving Rates Using ACT-Based (2Morrow Quit™) and
Mindfulness-Based (Craving to Quit®) Mobile Health Applications**

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Abstract

There has been a growing number of mobile health (mHealth) smartphone applications (apps) that target smoking cessation. There is concern that many smartphone apps for smoking cessation lack evidence-based practices, which harms the apps' efficacy and effectiveness. Two evidence-based mHealth apps that target smoking cessation are Acceptance and Commitment Therapy (ACT)-based 2Morrow Quit™ (2Q) and mindfulness-based Craving to Quit® (CTQ). 2Q is based on the ACT framework that teaches strategies to increase acceptance and reduce experiential avoidance, while making values-guided committed behaviour changes. CTQ is based on mindfulness training (MT) that teaches techniques to decouple the link between craving and smoking, established by associative and reinforcing processes. This study's purpose was to examine the effectiveness of 2Q and CTQ using a single-subject A1-B-A2-A3 design with a broad recruitment strategy that included anyone worldwide. There were two main areas explored: (1) to examine if ACT-based 2Q would reduce cigarette intake and cravings to smoke when compared to CTQ; and (2) to examine if having greater acceptance and commitment during post-intervention would predict better smoking outcomes (i.e., reduced cigarette consumption, reduced cravings, or quit smoking) when compared to CTQ. There was evidence of a small reduction in cigarette consumption for both intervention groups but was not statistically significant. There was limited evidence that both interventions were effective in reducing cravings to smoke because of observed differences, and no statistical significance found. There was limited evidence that higher acceptance and commitment levels predicted better smoking outcomes. It is speculated that 2Q is more engaging than CTQ; however, in terms of effectiveness, it is necessary to replicate this study with a larger sample size to produce adequate statistical power.

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Literature Review

Smoking as a Public Health Issue

Tobacco is a widespread risk factor and the leading preventable cause of disease, death and disability (World Health Organization [WHO], 2018a). According to the WHO, each cigarette contains approximately 4000 chemicals with at least 250 being harmful, and at least 50 causing cancer. In addition, the tobacco epidemic is one of the biggest public health threats that this world faces, killing more than 7 million people each year with 890,000 of those deaths, a result of individuals being exposed to second-hand smoke (WHO, 2018b).

The public health threat from cigarette smoking derives from two factors: (1) its prevalence is so high; and (2) it causes many harmful health effects (Institute of Medicine, 2015). In the United States (U.S.), a public health priority is the treatment of cigarette smoking and tobacco use disorders among adolescents because this is the critical period for neurodevelopment (Camenga & Klein, 2017). Once adolescents become addicted to tobacco, they face difficulty quitting into adulthood (Camenga & Klein, 2017).

The WHO (2010) reported that tobacco consumption has decreased in the past 30 years in industrialised countries because of an increase awareness of the hazards of tobacco use and the implementation of tobacco control policies; however, it is increasing in developing countries. The fitted and projected prevalence of smokers between 2000 to 2025 reported that the prevalence of smoking in most parts of the world has declined, particularly the Americas (e.g., Brazil, USA, Costa Rica), but in the Eastern Mediterranean (e.g., the United Arab Emirates [UAE], Qatar, Libya), the smoking prevalence trend remains flat (WHO, 2018a). Additionally, the Americas is projected to

reach the 2025 target of reducing smoking prevalence rates by 30%. The WHO projected that in the Eastern Mediterranean region, smoking prevalence will increase from 33.1% in 2010 to 36.2% in 2025 if anti-smoking initiatives are not strengthened in these regions.

Since 2003, the WHO (2015b) has established the framework convention on tobacco control (FCTC) with the objective “...to protect present and future generations from the devastating health, social, environmental and economic consequences of tobacco consumption and exposure” (p. 1). The WHO reported that the FCTC covers about 90% of the world’s population and legally binds parties to develop and implement evidence-based tobacco control measures to reduce the prevalence of tobacco in the world. The six tobacco control measures are abbreviated MPOWER – M: Monitoring tobacco use and prevention policies; P: Protecting people from tobacco smoke; O: Offering help to quit tobacco use; W: Warning about the dangers of tobacco; E: Enforcing bans on tobacco advertising, promotion and sponsorship, and R: Raising taxes on tobacco (see WHO, 2008; WHO, 2015b).

Economic and health costs

Most studies on the economic burden of smoking have been conducted in high-income countries, such as the United States (Lightwood, Collins, Lapsley, & Novotny, 2000; WHO, 2011a). The WHO asserted that healthcare costs associated with smoking accounts for 6-15% of national healthcare expenditures in high-income countries. The health costs associated with smoking tobacco has been costly on world economies with losses that exceed \$269 billion between 2013 to 2014 (WHO, 2018c). In recent years, there has been a decline in prevalence rates in high-income countries; however, the prevalence of smoking remains high in low- to middle- income countries (WHO, 2011a).

The Institute of Medicine (2015) reported that health-related costs contributing to the economic burden has immediate effects, such as increase inflammation, and

vulnerability to respiratory symptoms, including coughing, phlegm, wheezing, and dyspnea. The intermediate-term effects are individuals with an extensive smoking history, making them susceptible to impaired lung development and accelerated decline in functioning; susceptibility to infectious lung diseases; diabetes; periodontitis; and asthma exacerbation (Institute of Medicine, 2015). The long-term effect for long-term smokers causes chronic diseases, including cancer, cardiovascular disease, and chronic obstructive pulmonary disease (COPD; WHO, 2008). Second-hand smoke exposure refers to individuals exposed to the same tobacco toxins as cigarette smokers (WHO, 2008), making them vulnerable to intermediate and long-term health concerns (Institute of Medicine, 2015).

Policy makers have taken measures to reduce economic costs by implementing harsher smoking policies in high-income countries (WHO, 2011a). The United States (U.S.) Department of Health and Human Services (2014), highlighted that reducing the economic costs of smoking requires increasing the prices of tobacco up to a 10% increase, which is predicted to reduce cigarette consumption between 3-5%. New Zealand has implemented this form of tobacco control since 2010 when the government introduced a tax increase of 25.4% on roll-your-own cigarettes and 10% on manufactured cigarettes (Gathey, 2018). This has continued to increase over the years with 2018 bringing yet another 10% increase with cigarettes currently costing an average of \$25.45 (Gathey, 2018). Another example is the UAE, which is trying to meet world standards on health-related issues associated with smoking. In October 2017, a 100% value added tax (VAT) was added to tobacco products (Government.ae: The Official Portal of the UAE Government, 2018), and in January 2018 an additional tax of 5% was added to tobacco products (Webster, 2017).

The Effects of Nicotine Addiction

The criteria for nicotine dependence

Cigarette smoking is a compulsive behaviour pattern that is learnt over time through repeated cigarette smoking that makes it ultimately reinforcing (Shadel, Shiffman, Niaura, Nichter, & Abrams, 2000). This can make quitting smoking difficult, despite the desire to quit smoking and the awareness of the detrimental health consequences associated with smoking. West (2004) suggested that there must be a balance between one's dependency to cigarettes and the motivation to stop, which influences smoking cessation.

The Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) defines tobacco-use disorder (TUD) as the dependency on the drug nicotine from tobacco products (Camenga & Klein, 2017). The current symptoms for the DSM-5 TUD has increased its criteria from seven to 11 and lowered the threshold from two to three symptoms (Chung, Martin, Maisto, Cornelius, & Clark, 2012). The American Psychiatric Association (2013) stated that there must be at least two symptoms present in the last 12 months to be diagnosed with TUD. These include: (1) tobacco is taken in larger quantities over a longer period; (2) a persistent desire to cut down or control tobacco use; (3) a lot of time spent on activities necessary to obtain or use tobacco; (4) cravings or urges to smoke; (5) failure to attend to responsibilities and obligations due to tobacco use (e.g., work, home and school); (6) continued tobacco use despite persistent or recurrent social or interpersonal problems; (7) giving up on social, occupational or recreational activities because of tobacco use; (8) continued tobacco use in hazardous situations; (9) continued tobacco use despite the awareness of physical or psychological problems resulting from tobacco use; (10) tolerance for nicotine; and (11) withdrawal symptoms upon tobacco cessation.

Models of nicotine dependence

Operant conditioning

The operant conditioning framework has implications for understanding substance use addiction, including tobacco use. This framework postulates that an introduction of a pleasant stimuli (positive reinforcement) or removal of an unpleasant stimuli (negative reinforcement) increases the frequency of behaviour (Cooper, Heron, & Heward, 2007). With regard to smoking, the self-administration of tobacco (by inhaling the tobacco smoke) may be positively reinforced because of the positive effects of nicotine (e.g., the increase attention [from peers]), the increase concentration, and satiating appetite to maintain a lower body weight) that increases the future self-administration of tobacco use (Elwafi, Witkiewitz, Mallik, Thornhill, & Brewer, 2013). Shadel et al. (2000) said that dopamine, a neurotransmitter plays a role in establishing learnt behaviours, because when dopamine receptors are stimulated by nicotine, these receptors increase levels of dopaminergic activity, followed by reward (e.g. reduces anxiety, increases concentration). Shadel and colleagues added that learning that the consequence is rewarding, increases the likelihood that tobacco use will be repeated. On the other hand, the self-administration of tobacco may be negatively reinforced because of the positive effects of nicotine that reduces negative affect (or emotion) or the unpleasant effects resulting from tobacco abstinence (e.g., cravings, irritability, increased appetite, difficulty sleeping, and restlessness) that increases the future self-administration of tobacco use (Tiffany, Conklin, Shiffman, & Clayton, 2004).

Both positive and negative reinforcement play critical roles in nicotine dependence. Baker, Brandon, and Chassin (2004) conducted a review on the motivational influences on cigarette smoking and reported that negative reinforcement plays a larger role in exerting motivational influences on smoking cigarettes. This can be understood

when smokers abstain from smoking. Shiffman et al. (2002) found that for abstaining smokers, negative affect is highly associated with measures of smoking motivation because smoking reduces distress. This falls in line with withdrawal-based models that postulate on nicotine dependence arising from avoidance or escape from aversive situations (Tiffany et al., 2004). If nicotine alleviates negative affect, this would increase the opportunity for smokers to smoke to attain negative reinforcement (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004).

Furthermore, Cohen and George (2013) found that nicotine withdrawal depends on the frequency of cigarette intake. They reported that individuals who smoke intermittently (e.g., non-daily smokers) reported less likely to experience withdrawal symptoms, but for frequent smokers (daily smokers), it led to dependency, and high likelihood of anticipating withdrawal symptoms; therefore, smoking occasionally is primarily associated with positive reinforcement, but for daily chronic smokers, smoking tobacco shifts to negative reinforcement when continued use is likely to occur during escape or avoidance situations. Additionally, continued avoidance and suppression of aversive withdrawal signs increases an individual's likelihood of continued substance use and continued nicotine dependence (Eissenberg, 2004).

Classical conditioning

The classical conditioning framework was developed by Ivan Pavlov with his studies on the salivary conditioning in dogs. This framework suggests that behaviours become learnt through pairings between a neutral stimulus (NS) and a unconditioned stimulus (UCS), which when repeatedly paired, transforms the NS to a conditioned stimulus (CS), meaning that the NS ascribes the properties of the UCS so when the CS is presented alone, it learns to elicit a conditioned response (CR), which is similar to the unconditioned response (UCR) elicited by the UCS (Cooper et al., 2007).

There are several models in this framework, explaining addiction, dependence, and tolerance. One model suggests that the strength of the CR determines the degree of dependence on the substance, which is established through repeated pairings between the CS and the CR (Eissenberg, 2004). The CS is a stimuli, predictive of substance administration, such as substance-related cues or self-administration cues. The CR is characterized as a withdrawal state in the context of dependency, and suppression of this can lead to future substance use, including bingeing on substance use (Eissenberg, 2004).

Studies on cue reactivity postulates that when smoking-dependent individuals are exposed to cues (CS) most proximal to smoking administration (e.g., handling a lit cigarette, ashtray), these cues become triggers that cause individuals to elicit subjective (e.g., self-reported craving) and physiological (e.g., increased heart rate) responses (CR; Carter & Tiffany, 1999). These CRs occur because of repeated substance administration (UCS) and exposure to environmental cues (NS) related to smoking, which ascribe associative properties, such that when a smoking-related cue (CS) is presented alone, it signals smoking availability. Research also suggests that individuals exposed to people who smoke (i.e., distal cues) in the absence of proximal cues to smoke, reported cravings to smoke (Conklin, Robin, Perkins, Salkeld, & McClernon, 2008; Conklin, Salkeld, Perkins, & Robin, 2013; Shiffman et al., 2002). Stöffelmayr, Wadland, and Pan (2003) confirmed that family and friends who smoke become distal cues that influence smoking behaviours. These studies suggest that conditioned environments and social interactions become cues that trigger smoking because of paired associations. In turn, these cues play a role in maintaining smoking addiction.

Cultural context for dependence

The cultural context that people live in shapes their norms, values, and beliefs toward substance use. In cultures where cigarette smoking is acceptable, it can have

rewarding properties, in addition to tobacco properties, such as taking a break to smoke with colleagues to increase togetherness, taking a break from a boring task to give the smoker time to formulate thoughts, or giving the hands something to do when anxious (Fagerström, 2011). Forms of tobacco use can be culturally specific, such as the use of the dokha (i.e., a traditional middle eastern tobacco, mixed with flowers, herbs, spices, or fruit and is smoked through a wooden pipe) and hookah (i.e., charcoal on the top part of the component heats flavoured tobacco beneath it and has a tube connected to the base of the water pipe, which when inhaled, bubbles the water reservoir) in Middle Eastern regions (Aden, Karrar, Shafey, & Al Hosni, 2013), and the use of bidris in India (i.e., a small sun-dried, flaked tobacco, handwrapped in a dried temburni or tendu leaf and tied with a string WHO, 2010). Shadel et al. (2000) depicted that dependence to substance use develops in a specific cultural context due to the following: “(1) core values which dictate consumption behaviour; (2) the properties ascribed to substances; (3) the exchange value of substances (i.e., their relative worth in social exchanges); (4) the use of a substance to facilitate valued forms of social interaction; and (5) the manner in which substance use accords identity (e.g. the sign of social distinction)” (p. S17).

Social influences on dependence

From the social learning perspective, smoking is viewed as a learnt behaviour acquired through social interactions and modelling from exposure to individuals who smoke (Ennett et al., 2010). According to Shadel et al. (2000), social factors should be considered independently from substance dependence because such factors impact the access to and the use of substances.

For decades, studies have examined the relationship between modelling and the effects of smoking behaviour, confirming that smoking behaviour is influenced by the presence of others, peers and/or family members exposure to smoking (e.g., Chassin,

Presson, Sherman, Montello & McGrew, 1986; Harakeh, Engels, Vermulst, De Vries, & Scholte, 2006; Low, Shortt, & Snyder, 2012; Sharma, Grover, & Chaturvedi, 2010; Mason, Mennis, Way & Campbell, 2015; Shiffman et al., 2002; Tyas & Pederson, 1998; Vuolo & Staff, 2013). Further, parental attitudes/beliefs about substance use have helped researchers to understand the initiation of substance use, such as drinking, cannabis, illicit drug use, and tobacco use (Bahr, Hoffmann, & Yang, 2005; Mak, 2018).

Recently, Dimoff and Sayette (2016) conducted a literature review on the effect of the social context on smoking behaviour. The authors argued that laboratory research on smoking has largely ignored social contextual factors, but instead focused on neurobiological and pharmacological mechanisms. Social contextual factors have relevancy in understanding the underlying factors that may help researchers to understand smoking behaviour and smoking motivation. Despite few laboratory studies targeting the social context, it has been reported that smoking behaviour can be influenced by the presence of others (Dimoff & Sayette, 2016). The authors also commented that the social context not only influences self-perception and self-regulation but reinforces smoking and stagnates smoking cessation. Smoking cessation interventions should be investigated to consider the social environment and its impact on smoking behaviour so that strategies are designed to help smokers manage their social environment.

Relapse

Abstinence from tobacco precipitates withdrawal symptoms that include anger, frustration, anxiety, depression, difficulty concentrating, increased appetite, and cravings (Cohen & George, 2013). Several studies have examined relapse following abstinence from cigarette smoking to find that relapse makes users vulnerable to increased stress (Cohen & Lichtenstein, 1990), and major depressive disorder (MDD) for individuals with a history of MDD (Zvolensky, Bakhshaie, Sheffer, Perez, & Goodwin, 2015). Weight

concerns are also a predictor for relapse (see 'self-image' in 'psychosocial risk factors'). One study reported that brief abstinence from smoking affected cognitive and executive functioning, which led to relapse (Loughead et al., 2015).

The cognitive behavioural model of relapse highlights on the individual's response in high-risk situations and the interaction between the person (e.g., affect, self-efficacy, coping, and outcome expectations) and environmental risk situations (e.g., social influences, cue exposure, and access to substance; Marlatt & Donovan, 2005). If the person lacks the coping strategies to deal with the stressful event, then it is likely that he/she will give in to the temptation to smoke a cigarette. Further, a person vulnerable to the abstinence violation effect (i.e., the perceived control the person experiences following abstinence from the substance) that is accompanied by affective factors (e.g., guilt, shame, and hopelessness), and cognitive factors (e.g., the belief that the relapse is internal, global and uncontrollable), increases their chances toward relapse (Marlatt & Donovan, 2005).

Another perspective toward understanding relapse is from the behavioural literature, known as delay discounting. Delay discounting refers to the subjective value by which an individual devalues an amount of reward as a function of time to the receipt of that reward (Odum, 2011). Simply, delayed outcomes have less impact on individuals than immediate outcomes (Baker, Johnson, & Bickel, 2003). There have been several studies examining delay discounting and substance-use (e.g., Bickel & Marsch, 2001; Heil, Johnson, Higgins, & Bickel, 2006). With regards to tobacco use, higher discounting rates are associated with higher nicotine dependence (Sweitzer, Donny, Dierker, Flory, & Manuck, 2007). High discounting rates are also associated with a decreased likelihood to remain abstinent (i.e., relapse) following a tobacco cessation treatment (Krishnan-Sarin et al., 2007; Sheffer et al., 2014; Yoon et al., 2007). Sheffer et al. found delay discounting of

\$100 when compared to \$1000 had the strongest association with relapse across seven delays (1-day, 1-week, 1-month, 6-months, 1-year, 5-years, and 25-years); and that delay discounting and trait impulsiveness both showed stronger associations with days to relapse than measures of nicotine dependence and stress level. They found that when delay discounting rates were combined with nicotine dependence and stress measures, it maintained significant associations with days to relapse. The authors suggested adding a delay discounting measure in a tobacco dependence intervention, which could enhance the treatment for tobacco dependence, and when this same measure is added to a tobacco dependence intervention that is designed to decrease discounting rates, it has the potential to decrease relapse rates.

Cravings to smoke

A symptom of tobacco withdrawal is cravings to smoke (Etter, Le Houezec, and Perneger, 2003). Studies have reported an association between cravings and daily smoking (e.g., Baker et al., 2004; Killen & Fortmann, 1997); cravings are high in current smokers (Hughes, 1992); and for heavy smokers, smoking gives them control over negative moods and cravings (Piper et al. 2004).

According to Elfawi et al. (2013) associative memories are established through positive and negative reinforcing conditions. This suggest that both classical and operant frameworks are responsible for cravings to smoke. Elfawi et al. (2013) noted that positive (e.g., having a good meal) or negative cues (e.g., getting yelled at by your boss) trigger affective states (e.g., happiness or anger), and might then become associated with smoking, and induce the craving for a cigarette (Appendix P). In turn, giving in to the craving by smoking the cigarette, increases the salience of future cues and affective states associated with smoking, and with repeated pairings, cravings to smoke then becomes the central hub of this associative learning loop (Elfawi et al., 2013).

The Psychosocial Risk Factors of Tobacco Use

Self-esteem

There have been several studies that have found a relationship between self-esteem and smoking (e.g., Abernathy, Massad, & Romano-Dwyer, 1995; Kawabata, Cross, Nishioka, & Shimai, 1999). A main point these studies have highlighted is that there are gender differences in self-esteem, making it a predictor for tobacco use. Abernathy et al. (1995) found that adolescents' self-reports of cigarette smoking suggest that self-esteem may be a factor to female adolescents' smoking behaviour. Kawabata et al. (1999) conducted a study in the Japanese elementary and high school population to find that individuals who ever smoked (i.e., smoked at some point in their life) had lower self-esteem, and that grade and gender were significantly associated with self-esteem, such that having higher grades reflected higher self-esteem, and that males had higher self-esteem than females. The authors suggested to develop a smoking intervention program to help improve female self-esteem as this could be a preventive solution for female smoking initiation. On the contrary, Croghan et al. (2006) evaluated self-reported surveys to find that the association between tobacco use and self-esteem was not dependent on gender despite the fact young adult females have lower self-esteem when compared to young adult males, because self-esteem is perhaps modulated through other psychosocial factors (e.g., high risk behaviours, physical activity, family norms, peer interactions). Croghan et al. recommended that smoking cessation interventions for young adults should incorporate coping strategies for improving self-esteem.

Self-image

In industrialized countries, media portrayal of women attractiveness is being slim, maintained weight control, and dieting. Despite, females having a lower prevalence to tobacco use than males (WHO, 2010; 2018a), weight concerns (or the fear of gaining

weight) may instigate smoking initiation, and continued smoking to maintain the target weight, which acts as a barrier to smoking cessation (Levine, Perkins, & Marcus, 2001). Essentially, this may increase the likelihood of relapse if weight control is prioritized. One study reported a relationship between smoking initiation and dieting in high income countries (Austin & Gortmaker, 2001). The authors found that female dieters were four times more likely to become smokers at a 2-year follow up, in comparison to female non-dieters. Croghan et al. (2006) reported that female smokers have a higher body image dissatisfaction than male smokers, and that females' body image dissatisfaction was associated with frequent smoking. This study has implications for smoking initiation, body image dissatisfaction as a barrier to smoking cessation, and the potential for it to cause relapse.

Stress

Smoking tobacco products can be a coping mechanism to help individuals cope with negative emotions elicited from stressful life events (Cohen & Lichtenstein, 1990) because nicotine intake has been reported to reduce anxiety (Choi, Ota, & Watanukia, 2015; Pomerleau & Pomerleau, 1991). It is unclear whether nicotine alleviates the negative affect that arises from life stressors (Baker et al., 2004). Smokers' self-reports of negative affect is likely to predict relapse (Pomerleau & Pomerleau, 1991); and individuals with a history of depression are at a higher risk for relapse following abstinence (WHO, 2010). Research has reported that heavy smokers showed higher levels of anxiety/depression symptoms and negative life events in contrast to non-smokers (Billings & Moos, 1983).

Approaches to Quit Smoking

Nicotine replacement therapy (NRT)

Nicotine replacement therapy (NRT) is based on the physical dependence model (Cinciripini, Wetter, & McClure, 1997) that highlights that addiction to smoking results from nicotine exposure, tolerance, and withdrawal symptoms in the absence of nicotine (Gifford et al., 2004). NRTs provide an alternative form of nicotine by replacing nicotine from tobacco cigarettes and reducing the withdrawal symptoms (e.g., cravings to smoke; Silagy, Lancaster, Stead, Mant, & Fowler, 2007). NRTs may increase the likelihood of remaining abstinent (Silagy et al., 2007). NRTs include: injection, patch, gum, inhaler, nasal spray, and e-cigarette.

Nicotine gum replaces tobacco cigarettes to gum, which works by slowly releasing 90% of nicotine (via chewing the gum) within 20-30 minutes of ingestion (Jiloha, 2014). Jiloha further adds that the FDA has approved the 2-mg nicotine gum, which causes drug levels of plasma to rise slowly, and has been effective in increasing nicotine cessation and reducing relapse rates. Additionally, a 2-mg nicotine gum is found to reduce weight gain, which is a significant problem during smoking-cessation (Stitzer & Gross, 1988). The downside from using this form of NRT is the dependency on the gum and the difficulty to withdraw (Silagy et al., 2007).

Nicotine injection. The nicotine injection is designed to help people quit smoking by producing sensations that are equivalent to one inhalation of nicotine from a cigarette (Jiloha, 2014). Jiloha's review reported that smokers found the sensations following the injection pleasant, and it helped them to stop smoking for a short while. There are different dosages for the nicotine injection with a 22-mg nicotine injection being equivalent to 22 cigarettes (Jiloha, 2014). There is, however, a clinical concern to the safety of this treatment considering that high dosage can lead to toxicity. (Jiloha, 2014).

Nicotine trans-dermal patch comes in different sizes and typically delivers between 7-mg and 22-mg of nicotine into the bloodstream during a 16 or 24-hour period (Silagy et al., 2007). While the nicotine patch has benefits in increasing compliance, less frequent dosing, and fewer adverse effects, it does not address dosing for craving episodes, but can be addressed by combining this method with other NRTs (Jiloha, 2014). There have been some advocates for combining patches and gum NRTs (Kornitzer, Boutsen, Dramaix, Thijs, & Gustavsson, 1995; Puska et al., 1995).

Nicotine aerosols (inhalers) delivers nicotine via inhalation with each cartridge containing 10-mg of nicotine; and the recommended dosage is 6 to 16 cartridges for 12 weeks (Jiloha, 2014).

Nicotine nasal spray administers nicotine via the nose with the recommended dose of 8-weeks with a minimum of 8 doses per day and a maximum of 40 doses during a 3-month period (Jiloha, 2014). Jiloha commented that the side effect of this is a runny nose and nose irritation.

E-cigarette (or vaping) has been designed as a safer alternative for cigarette smokers because it emits doses of vaporized nicotine (or non-nicotine) without burning the tobacco and provides a similar sensation to inhaling tobacco smoke without the smoke (Cahn & Siegel, 2011; Kong et al., 2015). The e-cigarette comes in different forms: disposable, cartridge, and tank style e-cigarettes (Camenga and Klein, 2017). The authors further add with regard to the cartridge-type e-cigarette that each cartridge contains between 0 to 36-mg of nicotine per milliliter of solution. There is public concern regarding e-cigarettes serving as a gateway to tobacco products and nicotine addiction (Camenga & Klein, 2017; Cohen & George, 2013; Kong et al., 2015) because many e-cigarette users are non-smokers (Bunnell et al., 2015).

Silagy et al. (2007) provides an extensive review of NRTs that includes examining combination therapies.

Other pharmacological therapies

Pharmacotherapies are medications proven to reduce the reinforcing effects of nicotine and help the person quit smoking tobacco. Bupropion and Varenicline are currently medically approved pharmacotherapies for smoking cessation (Aubin, Luquiens, & Berlin, 2014).

Bupropion. Bupropion is an FDA approved tobacco cessation treatment, commonly used as an anti-depressant medication, and is effective in helping smokers spontaneously stop tobacco smoking (Jiloha, 2014). This is because the action of this anti-depressant is a neuronal reuptake inhibitor of dopamine and noradrenalin, which in the case of smoking cessation treats the neurochemical changes resulting from nicotine addiction and withdrawal. Hughes, Stead, Hartmann-Boyce, Cahill, and Lancaster (2007) review reported that 36 out of 49 trials found bupropion increases long-term smoking cessation.

Varenicline is a partial agonist $4\beta 2$ nicotinic acetylcholine receptor subtype (nACH), which releases a moderate amount of dopamine in the nucleus accumbens (an area responsible for reinforcement); therefore, reduces feelings of cravings and withdrawal (Ebbert et al., 2015).

Anxiolytics. Relapse often occurs because of stressful events, suggesting that nicotine may serve as a regulator of mood and anxiolytics may aid in this (Jiloha, 2014). There is inconsistent evidence that anxiolytics aids in smoking cessation (Hurt et al., 1997; Jiloha, 2014), but the ones documented so far - diazepam, meprobamate, metoprolol

and oxprenolol are effective as part of a smoking cessation treatment (Hughes, Stead, & Lancaster, 2000).

Nicotine Vaccine, such as NicVAX was designed for relapse prevention, which is a common problem following abstinence (Jiloha, 2014). It is administered via injection in the arm and delivers anti-bodies that bind to nicotine molecules, thus, making it difficult for these molecules to reach the receptor on reward sites that are responsible for addiction (Jiloha, 2014). There have been several nicotine vaccines under development, but none have been licensed for public use (Hartmann-Boyce, Cahill, Hatsukami, & Cornuz, 2012).

Quitlines

Quitlines are telephone-based programs, which services are mostly free for the caller, and aim is to help individuals quit smoking (Lichtenstein, Zhu, & Tedeschi, 2010). Quitline works by the individual calling a toll-free number (usually) and directed to services, such as mailed material, recorded messages, counselling, access to cessation medication, or a combination of these services (Lichtenstein et al., 2010). The WHO (2011c) reported that of the 53 countries known to provide toll-free national quitline services, high-income countries were overrepresented in these findings (60%), compared to low-income (4%), and middle-income countries (18%).

Behavioural interventions

Behavioural interventions for smoking cessation are derived from theories of behaviour change, and social cognitive and learning theories (Roberts, Kerr, & Smith, 2013). These interventions focus on the individual's motivation, self-efficacy, barriers and benefits, attitudes, subjective norms, and cues to action (Roberts et al., 2013). Two behavioural interventions that are effective for smoking cessation are: (1) cognitive behavioural therapy (CBT); and (2) acceptance and commitment therapy (ACT).

Cognitive Behaviour Therapy (CBT)

CBT is an evidence-based second wave behaviour therapy that combines both cognitive and behaviour therapies (Gaudiano, 2008). It is the most common behavioural intervention for smoking cessation (Singh, Starkey, & Sargisson, 2017) that focuses on identifying negative thought patterns and developing new and healthy ways of thinking, through exercises that include cognitive restructuring, emotion regulation training, mindfulness training, amongst others (Gaudiano, 2008).

There have been numerous studies reporting the effectiveness of CBT in facilitating smoking cessation when combined with pharmacotherapy, such as bupropion (Brown, Craig, Harris, Handley, & Harvey, 2007; Evins, Mays, Rigotti, Tisdale, Cather, & Goff, 2001) and transdermal nicotine patches (Webb, Sniehotta, & Michie, 2010). It has also shown effectiveness among smokers in a low SES group in a deprived area of London (Sykes & Marks, 2001); amongst African-American smokers (Webb et al., 2010); and female smokers who have weight concerns (Perkins et al., 2001)

Acceptance and Commitment Therapy (ACT)

ACT is an empirically-based third wave behaviour intervention, developed for over three decades by Hayes, Barnes-Holmes, and Roche (2001) who provide a modern account of human language and cognition that underlies functional contextualism. ACT differs from CBT because it does not teach people to control their thoughts, feelings, sensations, memories, and private events, but to be aware of, and accept them as they are (Hayes et al., 2001).

Relational Frame Theory (RFT) proposes that relational frames underpin language and cognition (Hayes et al., 2001). In RFT, one feature of relational frames (i.e., being able to discriminate relationships between stimuli) is known as derived stimulus relations,

which refers to forming relationships between stimuli or events without formal (or direct) training (e.g., knowing that ‘A is related to B’, and that ‘B is related to C’ forms the derived relation between ‘A and C’; Barnes-Holmes, Barnes-Holmes, McHugh, & Hayes, 2004; Hayes, Strosahl, & Wilson, 2012). When there are sufficient exemplars in one’s repertoire of responding to different types of relations that have been learnt through direct training, and when these relations are reinforced, it makes it possible to establish a derived stimulus relation for a novel exemplar (Barnes-Holmes et al., 2004). Hayes et al. (2012) described the three properties of relational frames: *mutual entailment* (i.e., the relation between two events or stimuli), *combinatorial entailment* (i.e., the relation among three or more related events or stimuli), and the *transformation of function* (i.e., the property of a stimulus relation is transferred to a neutral stimulus, which adopts the same function). From a smoking perspective, individuals’ exposure to social interactions, social/cultural norms, and media and marketing advertisements for or against smoking, allows them to form a repertoire of exemplars for responding to different types of smoking-related relationships. This study, however, will not go into depth about relational frames (see Barnes-Holmes et al., 2004; Hayes et al., 2012). Overall, relational frames have implications for understanding smoking behaviour.

A core component of ACT is psychological flexibility, which entails six core processes: acceptance, defusion, the self-as-context, flexible attention to the present moment, chosen values, and committed action (Hayes et al., 2001). Hayes et al. (2012) described each ACT component. *Acceptance* refers to psychological acceptance and behavioural willingness that requires the individual to make the value-based choice to come in contact with his/her private events or experiences (p. 77). *Defusion* refers to a reduction in the transformation of stimulus functions by altering the cues and content that influences the content and style of thinking and to allow the individual exposure to new learning experiences, cognitive flexibility and openness (Hayes et al., 2012). The *self-as-*

context refers to perspective-taking, highlighting on deictic relational frames (e.g., I/you, here/there, and now/then), which is key in ‘theory of the mind’ when an individual takes the perspective of another to understand deception or false beliefs (p. 87). Additionally, self-as-context is a conceptualized self, regarding how the individual views’ personal characteristics about himself because of relational networks that have shaped a consistent and logical account of who the person is (p. 89). When inconsistencies of oneself threatens one’s conceptualized self, this can evoke strong emotions and experiential avoidance and harm one’s psychological flexibility (Hayes et al., 2012). *Values* refer to freely chosen personal choices made in the presence of reasons that support or are against those reasons (p. 93). Values facilitate meaningful connection or purpose through one’s daily life actions where values establish other events as reinforcers (p. 94). *Committed action* is an extension of values that refers to “a values-based action, designed to create a pattern of action that is itself values based” (p. 95). When values are connected to the quality of action, it makes actions intrinsically reinforcing, and therefore gives meaning and purpose for actions undertaken, and ultimately leads to behavioural change (Hayes et al., 2012).

Mindfulness

Over the past few decades, mindfulness has been of academic interest because of its psychological benefits in improving mental health (e.g., anxiety, depression, borderline personality disorder, substance-use disorder; Appel & Kim-Appel, 2009; Baer, 2003; Hofmann, Sawyer, Witt, & Oh, 2010; Keng, Smoski, & Robins, 2011). Mindfulness dates back thousands of years in Buddhism, a spiritual practice, which allows insight into one’s emotional life to free a person from negative and destructive states (e.g., greed, hatred, and delusion; Coffey, Hartman, & Fredrickson, 2010). Mindfulness has been translated into a non-religious Western context since the 1970s (e.g., Kabat-Zinn, 1994), such as

mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1994), dialectical behaviour therapy (DBT; Linehan, 1993), Mindfulness-based relapse prevention (Bowen et al., 2009); and ACT (Hayes, Strosahl, & Wilson, 1999). Kabat-Zinn (1994, p. 4, as cited in Cullen, 2011), the developer of MBSR defined mindfulness as, “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally.” In DBT, mindfulness is describing experiences with words, fully participating in experiences, completing activities mindfully, and focusing on effective behaviour change (Linehan, 1993). In MBRP, it incorporates relapse prevention (RP), and principles from MBSR and mindfulness-based cognitive therapy (MBCT). Teaching mindfulness practices raises awareness of triggers; and allows the individual to monitor internal reactions and foster skillful behavioural choice (Bowen et al., 2009). In ACT, mindfulness is found within psychological flexibility, which is being conscious in the present moment and to change behaviour in the situation based on chosen values (Hayes et al., 2012). Psychological flexibility is fostered by six interrelated processes (as mentioned).

Coffey et al. (2010) review deconstructed mindfulness in mental health because at that time it had multiple definitions that made it difficult to form a clear understanding of its construct. They drew from Bishop et al. (2004) interdisciplinary team’s conceptualization of mindfulness that included acceptance and attention-based components. Coffey et al. (2010) further added to the mindfulness definition as the ability to identify and differentiate among emotions and successfully regulate negative emotions; and acceptance of one’s experience.

Overall, mindfulness as a construct has the potential to improve mental health and alleviate psychological disorders, including addiction.

Mobile health (mHealth)

Smartphones have allowed the development of new applications in the health field, and has intercepted different sectors, such as social, education, entertainment, and health (Bert, Giacometti, Gualano, & Siliquini, 2014). In turn, this has reduced the costs of health care not only because of the ease in accessibility and free accessibility for many applications (app), but the powerful ability to encourage healthy behaviours, reduce health problems, reduce the number of healthcare visits, support patient chronic disease self- management, and personalize, localize, and on-demand intervention (Kumar et al., 2013).

A smartphone is a cellular device containing sophisticated features, such as an in-built camera, global positioning system (GPS), Wi-Fi capabilities, built-in applications (apps), and offers real-time synchronous exchanges via social networks (Buolos, Brewer, Karimkhani, Buller, & Dellavale, 2014). Other important features of smartphone apps are: available at arm's reach, video/audio capabilities, visually engaging design, text available and unrestricted, sharable via social media, and tracking progress anywhere and anytime (Luxton, McCann, Bush, Mishkind, & Reger, 2011).

The term mHealth is a component of eHealth and is defined as a "... medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (Bert et al., 2014, p. 1). The apps on smartphones are often free and easy to download, which makes it convenient and cost-effective for most individuals (Bert et al., 2014).

Since 2010, there has been a growing number of mHealth users with more than 200 million mHealth apps downloaded (Silva, Rodrigues, de la Torre Díez, López-Coronadoc, & Saleem, 2015). Additionally, developing countries have increased their usage of mHealth services and applications (Silva et al., 2015; WHO, 2011b). With the

increasing number of mHealth users globally, research in this field has increased with research articles doubling since 2007 and 2008 (Silva et al., 2015).

Review

There have been several reviews on mHealth and health promotion (Bert et al., 2014; Hoepfner et al., 2016; Luxton et al., 2011; Patel et al., 2015; Silva et al., 2015). Generally the main concerns highlighted were: (1) there is limited evidence for the efficacy of mHealth applications (Bert et al., 2014; Kumar et al., 2013; Luxton et al., 2011); (2) the poor usability and acceptance by end-users (e.g., visual appearance, content, feedback; Bert et al., 2014; Luxton et al., 2011); (3) the generation gap in digital literacy (i.e., older adults may find it difficult to navigate the functions on the smartphone; Bert et al., 2014); and (4) the need for evidence-based mHealth apps (Luxton et al., 2011).

To further add, there have been specific reviews on mHealth and smoking cessation. Abroms, Padmanabhan, Thaweethai, and Phillips (2011) and Abroms, Lee Westmaas, Bontemps-Jones, Ramani, and Mellerson (2013) suggested that smoking cessation apps could be improved if they were integrated with evidence-based practices and 'Clinical Practice Guidelines'. Hoepfner et al. (2016) depicted that a common problem found in mHealth smoking cessation apps is the lack of tailored feedback. Hoepfner, Hoepfner, Kelly, Schick, and Kelly (2017) reported that there has been limited research in this area despite the fact that smartphones offer sophisticated tools that allow for interaction between participants and functionality. Patel et al. (2015) agreed that there were some top scoring apps (Craving to Quit® and 2Morrow Quit™ were not in this review) with high quality aspects; however, these apps should undergo further research to validate its efficacy and effectiveness for users.

While there certainly is a growing number of mHealth options for smoking cessation and it is likely that mHealth will continue to grow due to technological

advancements, it is, however, important to identify mHealth apps for smoking cessation that are evidence-based to help individuals effectively quit smoking successfully.

2Morrow Quit™

2Morrow Quit™ (formerly known as Smart Quit®) is an evidence-based behaviour change program (Bricker et al., 2014; Bricker et al., 2017), incorporating the ACT framework in the structure of its eight exercises (2Morrow Inc., 2016a, 2016b). ACT focuses on increasing acceptance to experience physical cravings, emotions, and thoughts, while making values-guided committed behaviour changes (Bricker et al., 2014).

Acceptance strategies were found to reduce cravings and consumption (Forman et al., 2007). Users create a quit plan, complete eight exercises received on separate days, receive customized messages and reminders, access any-time coaching, earn a certificate of completion, and are provided with relapse support (Appendix P).

Studies on 2Morrow Quit™

There have been a few studies conducted on 2Morrow Quit™ (Bricker et al., 2014; Bricker et al., 2017; Singh et al., 2017). Bricker et al. (2014) reported that SmartQuit® had 62-88% higher quit rates than QuitGuide; there was an increase in acceptance in cravings in the SmartQuit® arm, but not in the QuitGuide arm; and SmartQuit® participants opened this app 2.5 times more than QuitGuide participants. It seemed that the features of SmartQuit® app were more engaging. Bricker et al. (2017) compared the revised version (2.0) of SmartQuit® to the older version (1.0) to find that the revised version received higher user receptivity, modest quit rates (21%), and higher smoking reduction rates (75%) when compared to the older version. In addition, the authors speculated that perhaps program completion may be key to boosting the app's effectiveness because quit rates were much higher among participants who completed the program than participants who did not complete the program. Singh's (2016) initial thesis

led to the recent publication in Singh et al. (2017). Singh et al. reported that SmartQuit® was successful in reducing cigarette intake in 6 out of 10 participants following intervention, 7 out of 10 participants maintained or continued to reduce cigarette intake after 1-2 months of using the app, and 3 out of 10 participants remained smoke-free at the 13-months follow-up. Cravings to smoke did not subside over the short-term but reduced over time (Singh et al., 2017).

Craving to Quit®

Craving to Quit® is an evidence-based mindfulness training (MT) program, based on the smoking cessation curriculum developed and tested at Yale, and proven to be twice as effective as a leading quit smoking therapy (Brewer et al., 2011; Craving to Quit® by Claritas MindSciences, 2018). There is a link between craving and smoking, and mindfulness techniques moderates the relationship between both elements (Elfawi et al., 2013). As mentioned in ‘Cravings to smoke’, associative memories are established through positive and negative reinforcing conditions, making positive or negative cues trigger cravings to smoke (Elfawi et al., 2013; Appendix P). This program teaches the individual to use mindfulness-based strategies to decouple the relationship between cravings and smoking through learning to pay attention to affective states and bodily sensations that give rise to cravings and help ride out cravings.

Studies on Craving to Quit®

There have been a few studies on Craving to Quit®. Brewer et al. (2011) randomized 88 nicotine-dependent adults to receive either MT or the American Lung Association’s Freedom From Smoking (FFS) treatment. Both treatments were manualized and delivered by instructors who were experienced in MT for four weeks (twice weekly). In the MT condition, some of the exercises included exploring smoking as a habituated behaviour, triggered by an environmental, physical or mental stimulus, and developed

through associative learning; becoming aware of cravings and how they feel in the body using the acronym RAIN (Recognize, Accept, Investigate and Note what cravings feel like as they arise). The study reported that participants in the MT condition demonstrated a greater reduction in cigarette use and were more likely to maintain this reduction during a 17-week follow-up period when compared to participants in the FFS treatment condition.

Garrison et al. (2015) proposed a randomized controlled trial to compare the efficacy of mobile mindfulness training (MT) with experience sampling (e.g., a control condition that raises awareness about cravings and smoking) by placing individuals in either group. Participants would set a quit date – 3 weeks from the day they started, along with recording the number of cigarettes smoked per day, and would be given prompts (six times per day) to check in. Participants who remained abstinent for one-month would participate in the carbon monoxide monitoring, which measures CO levels. In 2018, Garrison et al. provided the first full-scale randomized controlled trial of Craving to Quit® app for smoking cessation. They reported that Craving to Quit® app did not reduce smoking consumption rates when compared with the control group, and there was no group difference in abstinence rates at 6-months. There was, however, preliminary evidence that MT via smartphone app might lessen the association between craving and smoking. This may support quitting in the long-term.

The Current Study

Using a single-subject, A1-B-A2-A3 design, the aim was to investigate the effectiveness of ACT-based 2Morrow Quit™ (2Q) and mindfulness-based Craving to Quit® (CTQ) smartphone mobile applications (app) with a worldwide population. I particularly aimed to investigate differences in cigarette intake and cravings to smoke between 2Q and CTQ interventions. First, I hypothesized that participants using ACT-

based 2Q would have reduced cigarette intake and cravings when compared to participants using the mindfulness-based CTQ app because in Singh et al. (2017) study, SmartQuit® effectively reduced the number of cravings to smoke and the number of cigarettes smoked. On the other hand, Garrison et al. (2015) reported that CTQ app did not reduce smoking consumption rates when compared to the control group, and preliminary evidence suggests that CTQ may lessen the association between craving and smoking. Second, I expected that since 2Q utilizes ACT principles that focuses on acceptance, participants would have an increased acceptance level and decreased experiential avoidance on the AAQ-II during post-intervention, resulting in better smoking outcomes (i.e., reduced smoking consumption, reduced cravings, or quit smoking) when compared to CTQ. Singh's (2016) initial study speculated that greater acceptance might lead to quitting smoking; however, there was no report of statistical significance. In a later study, Singh et al. (2017) found the ACT-component of 2Q helped reduced cravings over time at the 13-months follow-up. Similarly, this study wanted to examine if having greater acceptance predicted better smoking outcomes. Third, I expected that participants who obtained higher scores on the CQSS (i.e., higher commitment) during post-intervention, would have better smoking outcomes when compared to CTQ. There have been no studies on CTQ that have assessed commitment as a component for smoking cessation. Singh et al. (2017) study did not find that high commitment scores predicted successful outcomes. I wanted to confirm these findings. Fourth, I wanted to examine if cravings changed when measured throughout the phases (A, B, A2, A3) because this might provide valuable feedback as to whether both interventions are effective in reducing cravings.

Method

Participants

Participants were recruited mainly online through classified ads, google ads, and social media (e.g., Facebook, Twitter) by posting a banner (Appendix A). Fliers (Appendix B) were also placed on community boards and supermarkets in New Zealand and Dubai, UAE; organizations from affiliations of the researcher; word of mouth; newspapers (e.g., Waikato Times, Coffee News); and hospitals. Initially, this research aimed to recruit individuals from the Dubai population, but due to time constraints and recruitment restrictions, this was amended to include anyone worldwide. This recruitment strategy would allow a broader reach.

The inclusion criteria required individuals (1) to be at least 18 years old; (2) to own a smartphone; (3) to be able to speak and understand English; (4) to smoke at least 10 cigarettes per day; (5) to not be undergoing any psychological treatment; (6) to not be having a psychotic or affective disorder; (7) to not be using medication or an intervention to quit smoking; and (8) to report having motivation to quit smoking.

Apparatus

Participants were provided with information sheets, an eligibility survey, a consent form, and several questionnaires. Participants were required to complete the prerequisites before given full access to the assigned app. During this stage, participants were emailed clear instructions on how to access the app, provided with an individual login code to access the app, and notified that I would message them once a week on a random day to request for their daily cigarette consumption and craving rates.

Measures

Heaviness to Smoke Index (HSI)

HSI is composed of two questions, designed to test nicotine dependence using two questions from the Fagerstrom Tolerance Questionnaire and the Fagerstrom Test for Nicotine Dependence: (1) time to first cigarette of the day (TTFC); and (2) average number of cigarettes smoked per day (CPD; Heatherson, Kozlowksi, Frecker, Rickert, & Robinson, 1989; Appendix F). Borland, Yong, O'Connor, Hyland, and Thompson (2010) reported considerable consistency for both TTFC and CPD items with both items either independently or together predicting maintenance of quit attempts for at least one-month. The HSI calculates the number of CPD: 1-10, 11-20, 21-30, 31+; and the TTFC: less than or equal to 5 minutes, 6-30 minutes, 31-60 minutes, and 61+ minutes (Heatherson et al., 1989). Nicotine dependence was categorized by low (0-1), medium (2-4) and high (5-6; Chaiton, Cohen, McDonald, & Bondy, 2007).

Acceptance and Action Questionnaire-II (AAQ-II)

AAQ-II is a measure of psychological flexibility, a central component in ACT (Bond et al., 2011; Appendix G). For some individuals, smoking helps them avoid their thoughts and feelings, which might interfere with quitting smoking (Hernández-López, Luciano, Bricker, Roales-Nieto, & Montesinos, 2009). The AAQ-II is a 7-item scale that assesses action, flexibility, acceptance, and experiential avoidance that ranges from 1 'Never True' to 7 'Always True' (Bond et al., 2011). Higher scores on the AAQ-II reflect higher levels of psychological inflexibility and predicts greater psychological stress one-year later (Bond et al., 2011), while lower scores on the AAQ-II reflects greater acceptance and psychological flexibility (Gifford et al., 2004).

Commitment to Quitting Smoking Scale (CQSS)

The CQSS is an eight-item standardized questionnaire, assessing commitment to quit smoking on a 5-point scale from strongly disagree (5) to strongly agree (1; Kahler et al., 2007; Appendix H). The score of each item is summed up with higher scores reflecting higher commitment to quit smoking. Commitment has been associated with successful smoking cessation outcomes (e.g., Dalum, Schaalma, Nielson, & Kok, 2008; Kahler et al., 2007; Kleinjan et al., 2008). Kahler et al. study found that commitment is a valid construct in measuring smoking abstinence at post-treatment and 16 and 26 weeks after the quit date. The authors found participants with higher commitment scores showed better chance of abstinence during post-treatment.

The Cigarette Dependent Scale (CDS)

The CDS has several versions either containing a 114-item scale; a 12-item scale or a 5-item scale. This study used the 12-item scale, which consists of a 5-point likert scale, with scores ranging from 0-60 (Appendix I). The CDS-12 covers the main components from the DSM-IV and the ICD-10 definitions of dependence (Okuyemi et al., 2007). Higher scores indicate higher cigarette dependence, while lower scores indicate lower cigarette dependence. The cut-off score for low cigarette dependence is 12. Etter et al. (2003) reported the CDS-12 as a reliable measure of cigarette dependence, in terms of content validity and construct validity. They also reported that CDS-12 scores were higher in daily smokers than in occasional smokers, and these scores were linked with the strength of the urge to smoke during the last quit attempt.

Design

My research was a single-subject A1-B-A2-A3 design, which has a baseline (A1), intervention (B), post-intervention (A2), and two follow-up phases (A3; one-month [F1] and two-months [F2]).

Procedure

Pre-baseline

Individuals who expressed interest via email were emailed an information sheet (Appendix B), along with an eligibility survey (Appendix D) and a HSI questionnaire (Appendix F). The information sheet outlined the study's purpose. Individuals were granted eligibility in this study if they obtained a score of at least four on the HSI.

Baseline (A)

Participants who met the study's criteria were sent via email another information sheet (Appendix C) welcoming them to the study, specifying the study's requirements, how the information would be used, the right to withdraw, and contact information of the researcher, and supervisors. Participants who were non-eligible to participate in this study were sent an email notification (Appendix J). Participants who were eligible to participate were sent a consent form (Appendix E), links to other online questionnaires: The Commitment to Quitting Smoking Scale (CQSS; Appendix H); The Cigarette Dependence Scale (CDS-12; Appendix I); and The Acceptance and Action Questionnaire (AAQ-II; Appendix G), and a demographics questionnaire (Appendix K).

Participants were provided with a choice to either (a) record information each time they smoked a cigarette, and each time they experienced a craving to smoke for a duration of 3 to 5 days, or (b) to complete a retrospective questionnaire (Appendix L) only once during this phase to obtain information about their smoking patterns. Participants who chose (a) were sent a reminder at the end of each evening between 7PM to 9PM (adjusted according to their time zone) to send me their daily data records. For participants who chose (b), they immediately began intervention upon completion of the retrospective survey.

Intervention (B)

Participants were allocated alternatively to either the 2Q or CTQ apps and were provided with full access to the app (login ID and password). In addition, they were asked to set a quit date, then inform me so I could request for post-intervention data following this date. Participants were informed that their quit date could be changed at any time during the program. They were expected to complete the daily exercises (Appendix Q) and utilize the features of the app (e.g., check-in daily to record cravings and number of cigarettes smoked).

All participants were sent a text message once a week, on a randomly chosen day in the week, at the end of the day (between 7PM to 9PM) requesting their smoking and craving rates. Participants who did not record rates for that day were reminded to do so the following day.

Both app developers granted me access to the administrator's page so that I could monitor participant access to the app. If a participant did not access the app for a period of 7 days or more, I sent a text message to remind the participant to use the app (Appendix O). If this went on for at least 14 days, including not engaging with me (i.e., my weekly text message request for daily rates), he/she was automatically excluded from the study.

Demographics

Table 1 presents a summary of participants' demographics. There was a total of 45 individuals who expressed interest to participate in this study. Only 10 participants completed the prerequisites granting them access to one of two evidence-based apps.

Sex. There were 50% male and 50% female participants.

Age. There were 40% in the 25-34 age group; 40% in the 35-44 age group; and 20% in the 55-64 age group.

Country: There were three from New Zealand, two from U.S., three from Dubai, one from Qatar, and one from the United Kingdom.

Ethnicity. There were 20% Indian; 60% European/Caucasian; 10% Maori; and 10% mixed race.

Daily cigarette intake. Participants cigarette intake ranged from 10 to 30.

Number of years smoking. There were 90% who smoked for 6+ years, while 10% who smoked for 4-5 years.

Number of quit attempts. Previous quit attempts ranged from 1 to 10 times.

Household members who Smoke. There were 60% of participants who reported that either household members who smoked were: flatmates (30%), residents in the same building (10%), or partner/husband (30%). The remaining 40% did not have any household members who smoked.

Friends who smoke. All participants had friends who smoked.

Education. There were 40% who had a graduate degree; 30% had some college but no degree; 20% had a Bachelor degree; and 10% had a high school degree or equivalent.

Method of quitting smoking. Participants reported that in the past they used one or a combination of these methods: medication (30%), nicotine replacement (60%), e-cigarette (50%), cold turkey (40%), quitline (10%), and hypnosis (10%).

Intervention. There were six participants assigned to 2Q and four participants assigned to CTQ. My intention was to alternate participants into either app; however, there were few participants who changed their mind about participating either at the

intervention phase even when given the access code to the app or shortly after accessing the app. This was the reason for the uneven participation numbers in both groups.

Participation Status. Of the 10 participants, there were 60% who completed the program till their quit date; 30% were excluded for not engaging with the app and with me for at least 14 days; and 10% withdrew from the program.

Smoking Status. Only one participant reported quitting smoking.

Table 1

Summary of Participant Demographics

Gender	Age	Ethnicity	Daily Cigarette Intake	Number of Years Smoking	Number of Quit Attempts	Household Members who Smoke
M	25-34	Indian	12	6+	1	Flatmates
M	25-34	Indian	10	6+	10	No
F	25-34	Caucasion/European	20	6+	0	No
F	35-44	Caucasion/European	15-20	4 to 5	3	Partner/husband
F	55-64	Caucasion/European	20	6+	10	Partner/husband
M	35-44	Maori	11 to 20	6+	1	Partner/husband
M	35-44	Caucasion/West Indian	10	6+	several	Residents in the building
F	25-34	Caucasion/European	25	6+	3	No
M	35-44	Caucasion/European	30	6+	5	No
F	55-64	Caucasion/European	20	6+	3	Flatmates

Friends who Smokes	Education	Methods to Quit Smoking	Intervention	Participation Status	Smoking Status
Y	Graduate Degree	Medication	2Morrow Quit™	Completed	Did not quit
Y	Graduate Degree	Nicotine Replacement; e-cigarette	2Morrow Quit™	Completed	Unknown
Y	Graduate Degree	Cold Turkey	2Morrow Quit™	Excluded	N/A
Y	High school degree or equivalent	Nicotine Replacement; e-cigarette; medication	2Morrow Quit™	Completed	Did not quit
Y	Bachelor Degree	Cold Turkey; nicotine replacement; quitline; e-cigarette; hypnosis	2Morrow Quit™	Completed	Did not quit
Y	Some college but no degree	Cold turkey	2Morrow Quit™	Completed	
Y	Some college but no degree	Medication	Craving to Quit®	Withdrew	N/A
Y	Bachelor Degree	Cold Turkey; nicotine replacement; e-cigarette	Craving to Quit®	Excluded	N/A
Y	Graduate Degree	Nicotine Replacement; e-cigarette	Craving to Quit®	Completed	Quit
Y	Some college but no degree	Nicotine Replacement	Craving to Quit®	Excluded	N/A

Post-intervention (A2)

Upon reaching the quit date, participants were asked to record the number of cigarettes smoked and urges or cravings to smoke for a duration of 3 to 5 days. Additionally, participants were re-administered the following questionnaires – CDS-12, CQSS, and the AAQ-II.

Follow-up (A3)

Participants were administered two follow-up surveys (Appendix M), delivered at the on-month (F1) and two-months (F2) following post-intervention with the aim to measure app satisfaction, and their current smoking status. Additionally, participants were sent an information sheet providing general information about interventions and/or medications available to them (see Appendix N).

Results

Cigarette Consumption 2Morrow Quit™

Figure 1 presents the cigarette consumption rates for all participants assigned to 2Q taken during A, B, A2, and A3 (F1 and F2). This was plotted against the number of sessions (according to per day cigarette intake) for which cigarette intake was recorded. For participants 1 and 3 who completed the retrospective survey, the number of cigarettes smoked per day was taken and displayed by a single data point. Similarly, the follow-up phase only consisted of one data point indicating the number of cigarettes smoked per day.

Figure 1 shows all participants had high levels of cigarette intake during baseline ranging between 10 to 20 cigarettes. Cigarette consumption for participant 1 decreased during intervention ranging between 3 to 8 cigarettes. At post-intervention, cigarette consumption increased ranging between 8 to 10 cigarettes. This continued to decline to 7 cigarettes at F2. Cigarette consumption for participant 2 was the same as baseline rates during intervention;

however, decreased during post-intervention to 6 cigarettes. Participant 2 did not complete both F1 and F2 surveys. Cigarette consumption for participant 3 decreased during intervention ranging between 10 to 14 cigarettes, and during post intervention ranging between 8 to 10 cigarettes. During post-intervention, cigarette consumption ranged between 8 to 10 cigarettes. Cigarette consumption increased at F1 to 15 cigarettes. Cigarette consumption for participant 4 during intervention remained similar to baseline rates ranging between 17 to 21 cigarettes. This rate remained relatively stable during post-intervention ranging between 17 to 20 cigarettes and at F1, cigarette consumption was 20. Cigarette consumption for participant 5 decreased during intervention ranging between 9 to 10 cigarettes. During post-intervention, this continued to decrease ranging between 6 to 8 cigarettes. Both F1 and F2 surveys were not completed.

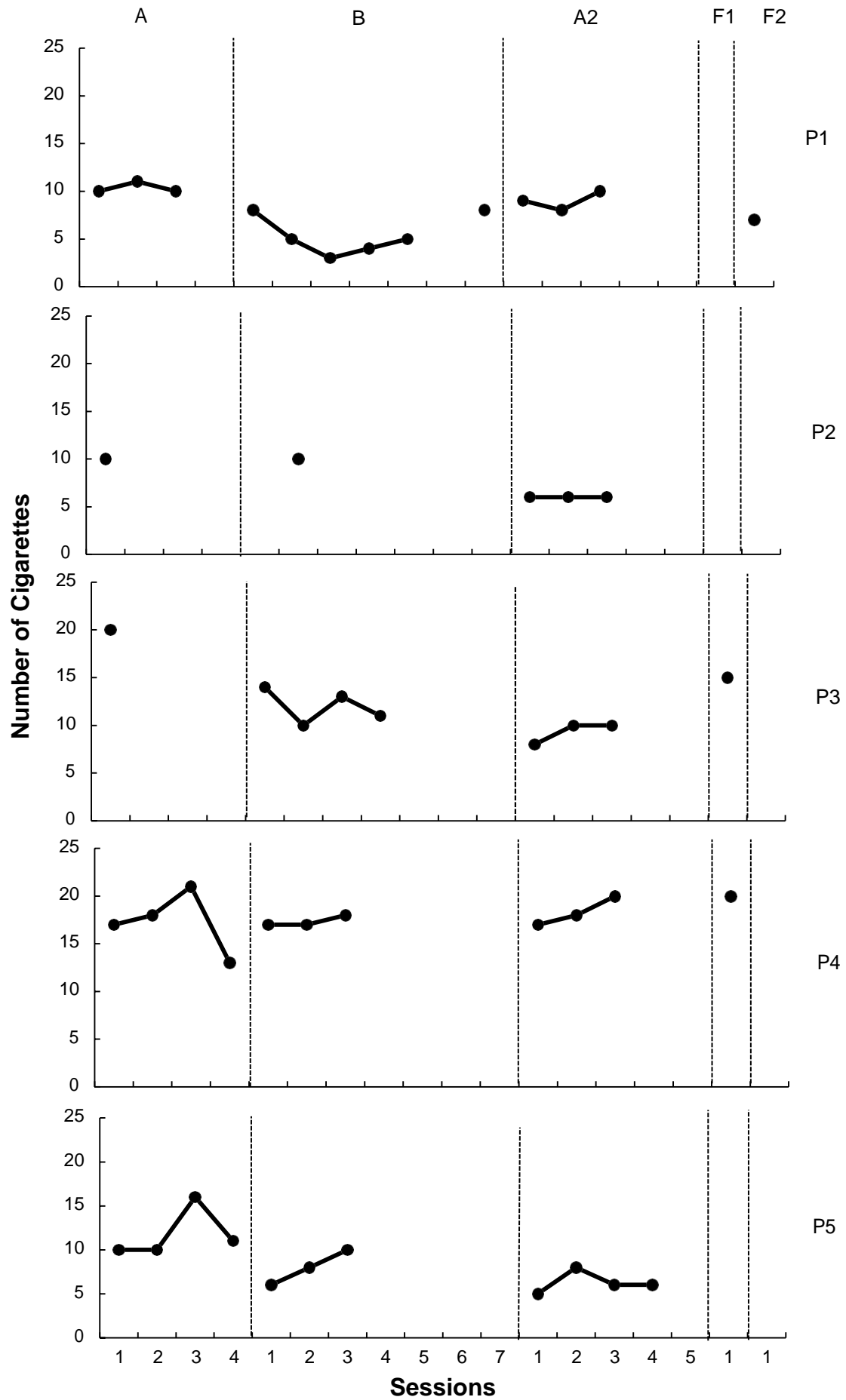


Figure 1. Cigarette consumption rates per session across all phases for each participant in the 2Morrow Quit™ intervention.

Cravings to Smoke 2Morrow Quit™

Figure 2 presents the craving rates for all participants assigned to 2Q taken during A, B, A2, and A3 (F1 and F2). This was plotted against the number of sessions (according to per day cravings) for which craving to smoke was recorded.

Figure 2 displays most participants having low levels of cravings during baseline ranging between 0 to 4. Participant 1 showed an increased number of cravings during intervention ranging between 5 to 7 with similar rates reported during post-intervention ranging between 6 to 9. At F2, cravings ranged between 8 to 10. Participant 2 showed an absence in cravings during intervention, and an increased in cravings during post-intervention at 10. Both F1 and F2 surveys were not completed. Participant 3 showed an increased number of cravings during intervention ranging between 8 to 10 with slight increases during post-intervention ranging between 10 to 12. At F1, cravings remained at a similar rate at 10+. Participant 4 showed little to no difference in cravings during intervention and post-intervention. Participant 4 did not report cravings at F1. Participant 5 showed similar craving rates during intervention, followed by an absence of cravings for the first three days with an increase to 4 during post-intervention. Both F1 and F2 surveys were not completed.

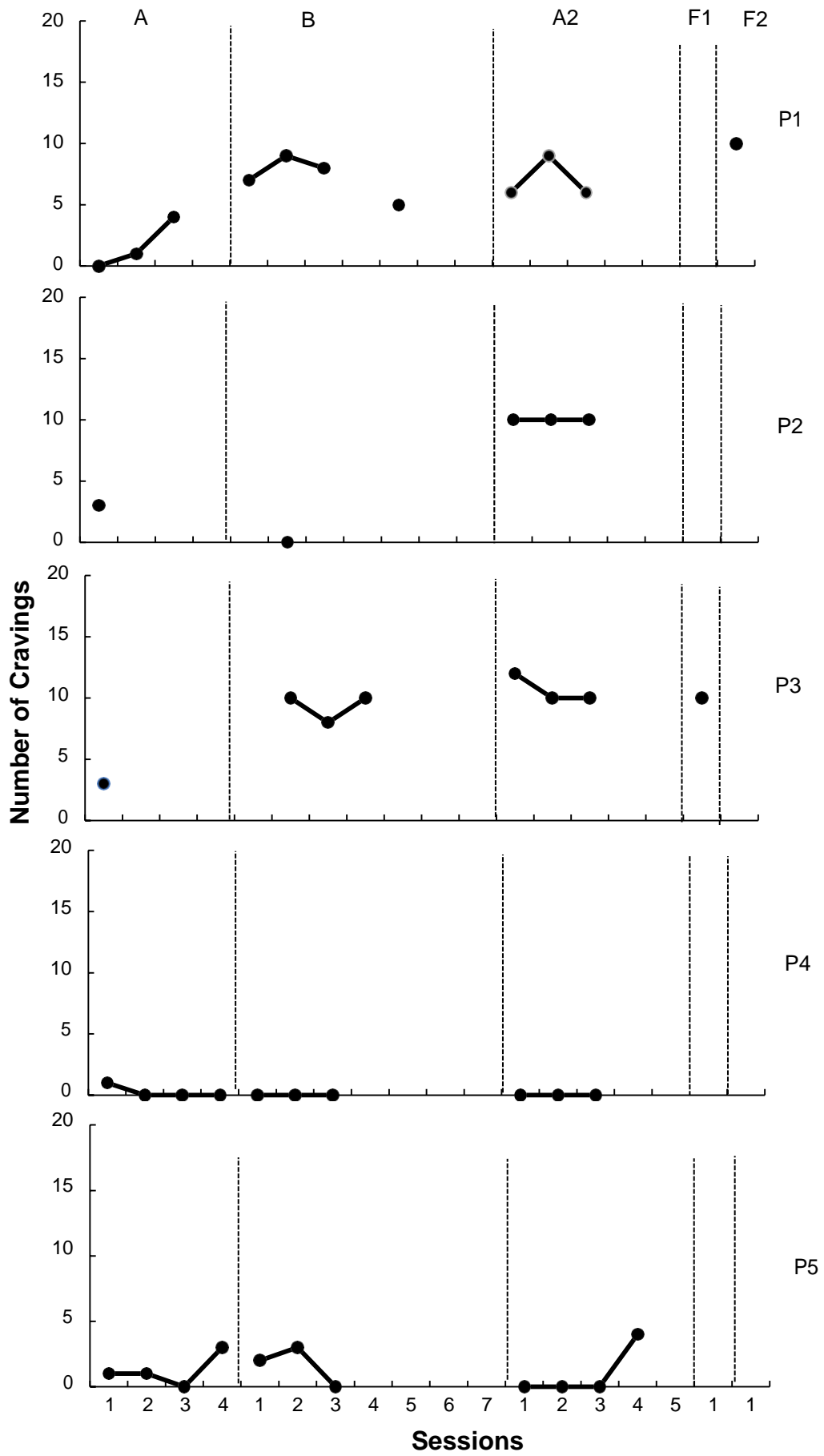


Figure 2. Craving to smoke rates per session across phases for each participant in the 2Morrow Quit™ intervention.

Cigarette Consumption Craving to Quit®

Figure 3 presents the cigarette consumption for one participant who remained in the CTQ intervention. The data was taken during A, B, A2, and A3 (F1 and F2). This was plotted against the number of sessions (according to per day cigarette consumption) for which cigarette intake was recorded.

Figure 3 displays high cigarette consumption during baseline ranging between 11 to 30 cigarettes. Cigarette consumption decreased during intervention ranging between 17 to 24. This continued to decrease during post-intervention to 15 to 21. At F1, there was a significant reduction in cigarette consumption to 0.

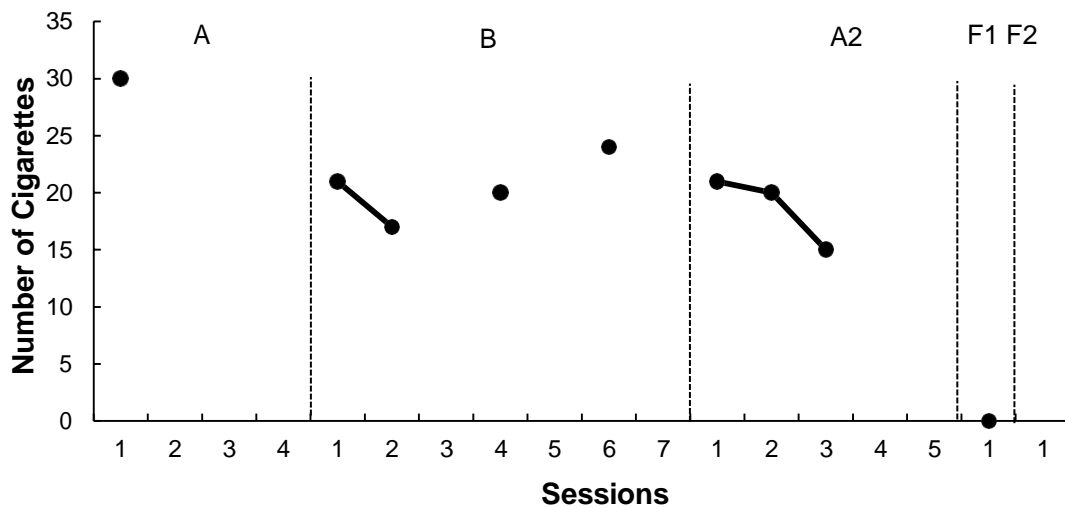


Figure 3. Cigarette consumption rates per session across all phases for one participant in the Craving to Quit® intervention.

Cravings to Smoke Craving to Quit®

Figure 4 presents the craving rates for one participant assigned to CTQ taken during A, B, A2, and A3 (F1 and F2). This was plotted against the number of sessions (according to per day cravings) for which craving to smoke was recorded.

Figure 4 displays low cravings during baseline at 10+. Cravings increased during intervention ranging between 20 to 30. Cravings slightly decreased during post-intervention ranging between 15 to 20. At F1, there was a significant decline in cravings to 0.

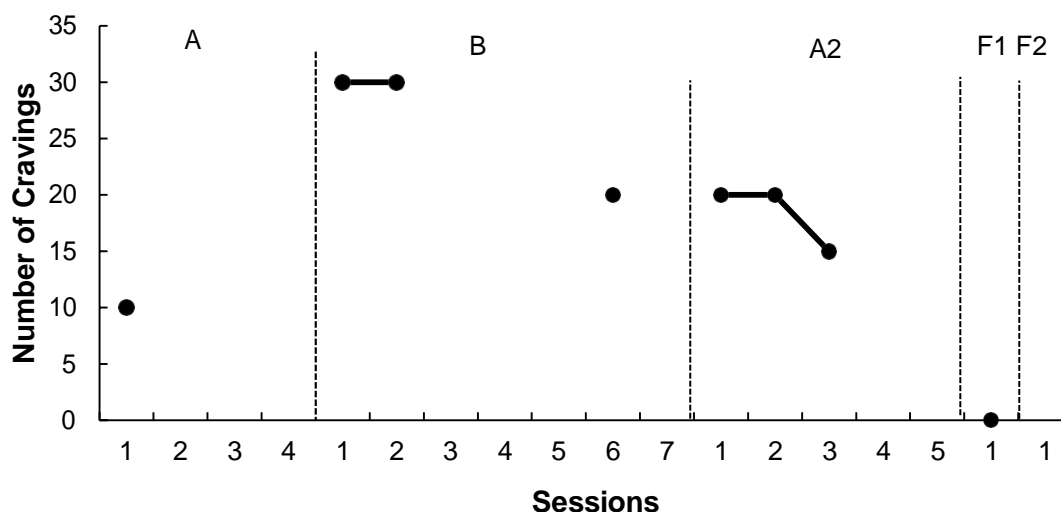


Figure 4. Cravings to smoke rates per session across phases for one participant in the Craving to Quit® intervention.

Intervention Comparison

2Morrow Quit™

Table 2 presents the individual differences in consumption rates. This was calculated by tallying the total number of cigarettes smoked for each individual and dividing it by the number of sessions across each phase. At baseline, the highest average cigarette consumption was 17.25, while the lowest average cigarette consumption was 10. At intervention, the highest average cigarette consumption was 17.33, while the lowest average cigarette

consumption was 5.5. At post-intervention, the highest average cigarette consumption was 18.33, while the lowest average cigarette consumption was 6. At follow-up, the highest average cigarette consumption was 20, while the lowest average cigarette consumption was 7. The average group mean showed a decrease in cigarette consumption rates during baseline and post-intervention at 1.08.

Gender differences were also reflected in this data. At baseline, females showed the highest average cigarette consumption at 17.25, while males showed 11.75. At intervention, females showed the highest average cigarette consumption at 17.33, while males showed 10. At post-intervention, females showed the highest average cigarette consumption at 18.33, while males showed 9. At follow-up (for the participants that completed this phase), females showed the highest average cigarette consumption at 20, while males showed 7. This suggests that females in this study generally smoked more than their male counterpart.

Table 2

Summary of Participant Mean Cigarette Consumption Rates

Participant	Gender	Baseline	Intervention	Post-intervention	F1	F2
<i>2Q</i>						
1	M	10.3	5.5	9	-	7
2	M	10	10	6	-	-
3	F	20	12	9.33	15	-
4	F	17.25	17.33	18.33	20	-
5	M	11.75	8	6.25	-	-
<i>CTQ</i>						
6	M	30	20.5	18.67	0	-

Note. - = participant did not report data.

Table 3 presents the individual differences in craving rates. This was calculated by tallying the number of cravings smoked and dividing it by the number of days in each phase. At baseline, the highest average cravings was 1.6, while the lowest average cravings was

0.25. At intervention, the highest average cravings was 9.33, while the lowest average cravings was 0. At post-intervention, the highest average cravings was 10.67, while the lowest average cravings was 1. At follow-up, the highest average cravings was 10+, while the lowest average cravings was between 8 to 10. The average group mean showed an increase in craving rates during baseline and post-intervention at 10.67.

Gender differences were also reflected in this data. There was a small difference in craving rates between males and females during baseline. At intervention, females showed the highest average cravings at 9.33, while males showed 7.25. At post-intervention, females showed the highest average cravings at 10.67, while males showed 10. There were only a few participants who completed the follow-up survey, and for those who did, their craving rates were comparable to each other. Generally, females in this study experienced stronger cravings than their male counterpart.

Table 3

Summary of Participant Mean Craving Rates

Participant	Gender	Baseline	Intervention	Post-intervention	F1	F2
<i>2Q</i>						
1	M	1.6	7.25	7	-	8 to 10
2	M	3	0	10	-	-
3	F	3	9.33	10.67	10+	-
4	F	0.25	0	0	-	-
5	M	1.25	1.67	1	-	-
<i>CTQ</i>						
6	M	10	27.5	18.33	0	-

Note. - = participant did not report data.

Craving to Quit®

There was no individual comparison and gender comparison for cigarette consumption and craving rates for CTQ, considering that only one participant remained in this program.

Overall, four out of five participants (1, 2, 3 and 5) in 2Q reduced cigarette consumption during post-intervention. The one participant in CTQ reduced cigarette consumption during post-intervention. Two participants in 2Q (1 and 5) reduced cravings during post-intervention. At follow-up, cravings for participants in 2Q remained at a similar rate with a slight increase or decrease. The one participant in CTQ intervention did not reduce craving to smoke during post-intervention; however, at the one-month follow-up, cravings were absent.

Questionnaire Scores

Acceptance and Action Questionnaire-II (AAQ-II)

Figure 5 illustrates the AAQ-II scores for each participant in either the 2Q and CTQ intervention taken during baseline and post-intervention. Higher scores on the AAQ-II during post-intervention indicated greater psychological inflexibility, while lower scores on the AAQ-II indicated greater psychological flexibility and acceptance.

2Morrow Quit™

Figure 5 displays participant 1 and 4 having a slight increase in AAQ-II scores at post-intervention, while participant 3 showed a larger increase in AAQ-II scores during post-intervention. Participant 2 and 5 showed no difference in scores during both baseline and post-intervention phases. Participant 5 showed the lowest AAQ-II scores.

Table 4 provides a between-subjects' descriptive summary (*M* and *SD*) of their AAQ-II scores taken during baseline and post-intervention. It shows the group ($n = 5$) mean score

during baseline was 18.80 ($SD = 8.35$), while the mean score during post-intervention was 22 ($SD = 9.57$).

Craving to Quit®

Figure 5 shows participant 6 having a slight increase in AAQ-II scores during post-intervention (22, 24).

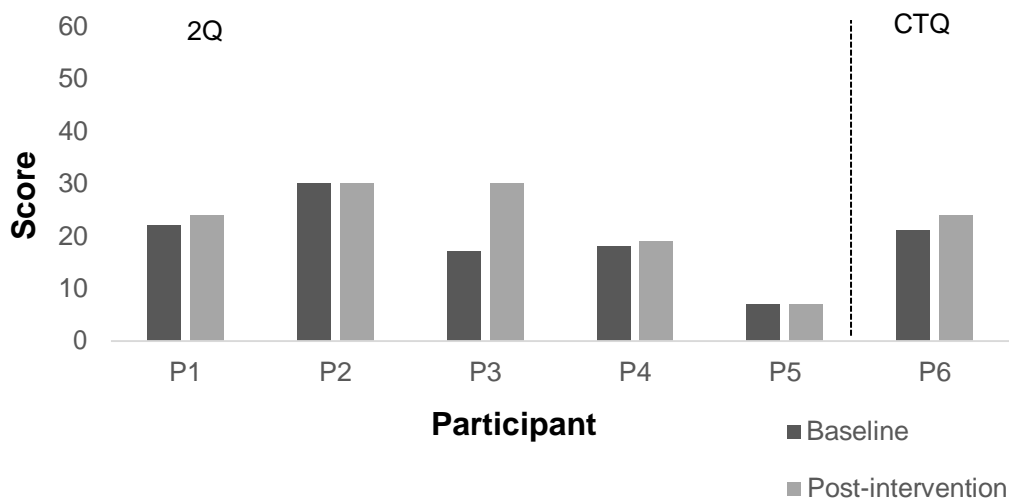


Figure 5. AAQ-II scores during baseline and post-intervention for all participants in 2Morrow Quit™ and Craving to Quit®

Analysis

A Shapiro-Wilk's test ($p > .05$; Shapiro & Wilk, 1965) and visual inspection using Q-Q plots and histograms were used to assess normality. The data showed all variables were approximately normally distributed.

A paired sample t-test was conducted to compare if there was a significant difference in AAQ-II scores during baseline and post-intervention. This was only conducted for participants using 2Q, since CTQ had only one participant.

A paired sample t-test found no significant difference in AAQ-II scores during baseline ($M = 18.80$, $SD = 8.35$) and AAQ-II scores during post-intervention ($M = 22.00$, $SD = 9.57$); $CI [-10.08, -3.68]$, $t(4) = -2.09$, $p = 0.845$, $d = -0.58$. Cohen's (1992) criteria for effect size indicated a moderate effect ($d = 0.50$). The data supports the null hypothesis that there is no difference in scores during baseline and post-intervention.

Commitment to Quit Smoking Scale (CQSS)

Figure 6 illustrates the AAQ-II scores for each participant in either 2Q and CTQ intervention taken during baseline and post-intervention. CQSS scores reflect a degree of commitment with higher scores showing greater commitment, while lower scores showing lesser commitment.

2Morrow Quit™

Figure 6 shows participant 1 and 3 with slightly lower scores during post-intervention. Participant 4 and 5 displayed higher scores during post-intervention. Participant 2 displayed no difference in scores during baseline and post-intervention.

Table 4 shows the group ($n = 5$) mean score during baseline was 32.40 ($SD = 6.23$), while the mean score during post-intervention was 33.60 ($SD = 5.68$).

Craving to Quit®

Figure 6 shows participant 6 with a slightly lower CQSS score during post-intervention (36, 35).

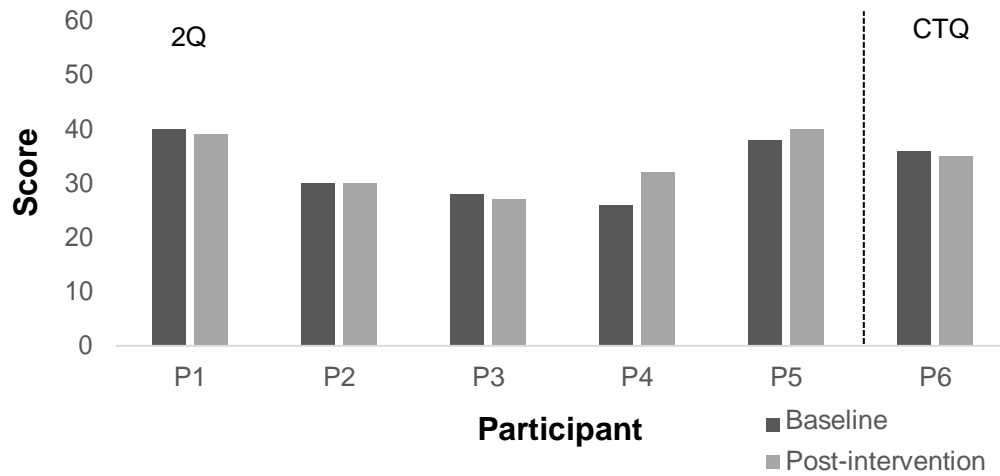


Figure 6. CQSS scores during baseline and post-intervention for participants in 2Morrow Quit™ and Craving to Quit®.

Analysis

A paired sample t-test found no significant difference between CQSS scores during baseline ($M = 32.40$, $SD = 6.23$) and post-intervention ($M = 33.60$, $SD = 5.68$); CI 95% [-4.86, 2.46], $t(4)$, -0.91, $p = 0.41$, $d = -0.41$. Cohen's (1992) criteria for effect size indicated a small effect ($d = 0.20$). This finding supports the null hypothesis that there is no difference in CQSS scores during baseline and post-intervention.

Cigarette Dependence Scale (CDS-12)

Figure 7 illustrates the CDS-12 scores for each participant in either 2Q and CTQ intervention taken during baseline and post-intervention. A higher CDS-12 score indicated a higher level of dependence, while a lower CDS-12 score indicated a lower level of dependence.

2Morrow Quit™

Figure 7 shows participant 1 and 3 had higher scores during post-intervention, while participant 4 and 5 had lower scores during post-intervention. Participant 2 showed the same scores during baseline and post-intervention.

Table 4 shows the group ($n = 5$) mean score during baseline was 46.20 ($SD = 8.76$), while the mean score during post-intervention was 46.60 ($SD = 11.37$).

Craving to Quit®

Figure 7 shows participant 6 had a slightly lower CDS-12 score during post-intervention (56, 53).

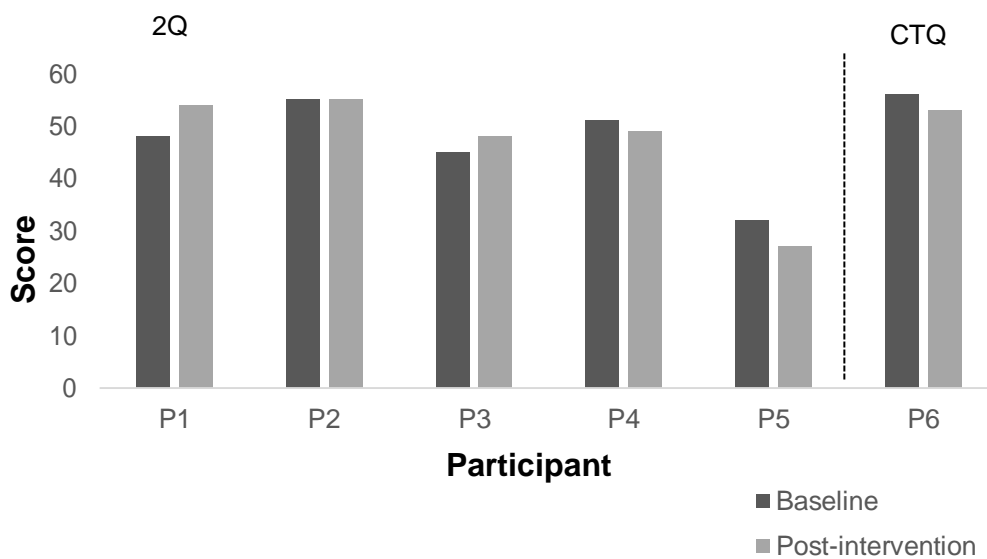


Figure 7. CQSS scores during baseline and post-intervention for participants in 2Morrow Quit™ and Craving to Quit®.

Analysis

A paired sample t-test found no significant difference between CQSS scores during baseline ($M = 46.20$, $SD = 8.76$) and post-intervention ($M = 46.60$, $SD = 11.37$); CI 95% [-5.712, 4.912], $t(4)$, -2.01, $p = 0.85$, $d = -0.94$. Cohen's (1992) criteria for effect size indicated

a large effect ($d = 0.90$). This finding supports the null hypothesis that there is no difference in CDS-12 scores during baseline and post-intervention.

Table 4

Descriptive Summary for Questionnaire Scores at Baseline and Post-Intervention for 2Morrow Quit™

Intervention

	Baseline			Post-Intervention		
	N	M	SD	N	M	SD
Acceptance and Action Questionnaire (AAQ-II)	5	18.80	8.35	5	22.00	9.57
Cigarette Dependency Scale (CDS-12)	5	46.20	8.76	5	46.60	11.37
Commitment to Quit Smoking Scale (CQSS)	5	32.40	6.23	5	33.60	5.68

Note. n = number of participants. M = Mean. SD = Standard Deviation

Measures comparison

A Pearson correlation coefficient was conducted to examine the differences in scores during baseline and post-intervention among all measures in the 2Q group ($n = 5$; Table 5). Table 5 reports a strong positive association between AAQ-II and cigarette consumption, $r = 0.94$ and there was significance ($p = 0.01$). This suggests that when AAQ-II scores increase so does cigarette consumption rates. All other measures had non-significant relationships despite the fact r ranged from small to large.

Table 5

Correlations for all Self-Report Measures

	AAQ-II	CDS-12	CQSS	Cigarette Consumption	Craving to Smoke
Acceptance and Action Questionnaire (AAQ-II)	1	.41	-.43	.95*	.59
Cigarette Dependency Scale (CDS-12)	.41	1	-.65	.44	.67
Commitment to Quit Smoking Scale (CQSS)	-.43	-.65	1	-.22	-.82

Note. * $p < .05$ level, 2-tailed

Engagement

Engagement during the intervention was monitored by: (1) participants frequency of opening the app; and (2) engagement with the researcher's once a week text message requesting for cigarette consumption and craving rates.

Table 6 shows participants engagement with either 2Q and CTQ app. For 2Q, this was indicated by the progress bar (percentage) of program completion; and for CTQ, this was indicated by the number of exercises completed. The highest progress was 91% (participant 3), followed by 64% (participant 5), 60% (participant 1), 40% (participant 2), and 44% (participant 4). The longest duration spent using the app ranged between three to five weeks. For CTQ, the one participant completed one exercise out of 22 and engaged with the app for a duration of 10 weeks.

Table 6

Summary of Participants' Engagement with 2Morrow Quit™ and Craving to Quit®

ID	Progress	Duration of app use
<i>2Q</i>		
1	60%	5 weeks
2	40%	4 weeks
3	91%	4 weeks
4	44%	3 weeks
5	64%	5 weeks
<i>CTQ</i>		
6	1/22 exercises	10 weeks

Follow-up

2Morrow Quit™

Only three participants completed the follow-up survey – two at F1 and one at F2. Participants 1 and 3 opened the app 1-2 times each day; and participant 5 opened the app 0-1 times each day. All three participants reported 'I did not quit' in response to 'smoking status'. For participant 1, smoking was triggered by work-related stress. For participant 3, smoking was triggered by people smoking, drinking alcohol, caffeine, and surgery. For participant 5, it was triggered by people smoking, and drinking caffeine. Only one participant (1) used e-cigarettes in the last 30-days. Two participants (1 and 3) reported that they 'strongly disagree' that the app helped them with their cravings. One participant (4) remained 'neutral' on this. All participants reported that this app did not help them to reduce the number of cigarettes smoked. Satisfaction with the app on a scale of 1 to 10 (strongly disagree to strongly agree) was reported at a '3' (participant 1), '8' (participant 3), and '5' (participant 4). All participants stated that they were 'not motivated' to stay smoke-free. Participants stated strongly agreed (participant 1) and strongly disagreed (participant 3 and 4) that the app has room for improvement. More specifically, the app should improve in terms of being user-friendly (participant 1). Two effective aspects of the app that were effective in reducing or quitting smoking were liking some videos that were thought to be positive (participant 4).

The other two participants did not specify. There were no specific aspects of the app liked and/or disliked. Participant 1 found the app confusing. Participant 3 was satisfied with the app despite the fact she did not quit smoking and felt that one had to be ready to stop and be fully committed to do so for this program to work. Participant 4 reported that she liked that the app is on the phone and has intentions of using it. Two participants (3) reported a 'yes' to recommending this app to someone, while one participant (1) reported a 'maybe'.

Craving to Quit®

Participant 6 completed the F1 survey. It was reported that the app was opened 6+ times each day. It was reported 'I quit' in response to smoking status. Smoking was triggered by people smoking, drinking alcohol, caffeine, and work-related stress. Other types of tobacco used in the last 30-days were e-cigarettes and cigars. This app was reported to help with cravings. Despite the fact this participant quit smoking, it was reported that this app did not help reduce the number of cigarettes smoked. Perhaps, this was an error. This participant reported 'very motivated' to stay smoke-free. It was 'undecided' if this app has room for improvement.

Furthermore, it was reported that the app was very good and useful but could not benefit enough because of work pressure. Two aspects of the app that were reported as most effective were the app check-in notification reminder, and the daily count of the cigarettes smoked. Considering that this participant only completed one out of 22 exercises on the app, it may be that the check-in reminder and daily count were the features that benefitted this participant the most. Lastly, it was reported a 'yes' to recommend this app to someone.

Discussion

The aim of this study was to examine the effectiveness of ACT-based 2Morrow Quit™ and mindfulness-based Craving to Quit® with a worldwide sample by investigating the differences in smoking consumption and cravings to smoke rates. There were four aspects this study explored. First, ACT-based 2Q intervention would have reduced smoking intake and cravings when compared to the mindfulness-based CTQ intervention. Second, participants in the 2Q intervention would have an increased acceptance level (i.e., lower AAQ-II scores) during post-intervention, resulting in better smoking outcomes (i.e., reduced smoking consumption, reduced cravings, or quit smoking) when compared to CTQ. Third, participants in the 2Q intervention who obtained higher scores on the CQSS during post-intervention, would have better smoking outcomes when compared to CTQ. Fourth, cravings data were taken throughout the phases (A-B-A2-A3) to examine if there were changes in craving rates.

This study found limited evidence to support that either app was more effective than the other. There was no statistical significance that either app increases acceptance and commitment as measured by the AAQ-II and CQSS. There was limited evidence that both apps were effective in reducing cravings during post-intervention and follow-up phases as there was no significant findings. On the other hand, 2Q and CTQ showed a small reduction in reducing cigarette consumption but was not statistically significant.

Acceptance

Acceptance is a central component of ACT because high levels of acceptance overrides experiential avoidance and allows the individual to focus on strategies to reduce internal experiences (Hayes et al., 2012). Both ACT and mindfulness differs from CBT because it encourages individuals not to control thoughts, feelings, sensations, memories and private events but to be aware of, and accept them as they are (Hayes et al., 2001). This study

measured acceptance by using the AAQ-II. Lower scores on the AAQ-II reflect greater acceptance and psychological flexibility, while higher scores on the AAQ-II reflect experiential avoidance and psychological inflexibility. Higher acceptance meant that participants would be more accepting of their internal experiences. This study followed similarly to Singh (2016) and Singh et al. (2017) study where higher acceptance translates to reduced cigarette consumption, reduced cravings over time, or quitting smoking.

This study did not find *participants in the 2Q intervention having an increased acceptance and decreased experiential avoidance at post-intervention resulting in better smoking outcomes when compared to the CTQ intervention*. There was no participant in 2Q who showed higher acceptance at post-intervention. This was also found with the one participant in CTQ. Furthermore, I conducted a t-test on participants in 2Q to confirm that there was no significant difference in the mean scores for the AAQ-II during baseline and post-intervention. This finding was similar to Singh (2016) who could not report a significant difference in acceptance scores when comparing both baseline and post-intervention phases. While the small sample size can be a reason for not finding statistical significance (Greenland et al., 2016), there was also no observed differences in this study to confirm this.

Gifford et al. (2004) reported greater acceptance and a decrease in experiential avoidance for participants in the ACT condition, along with better long-term smoking outcomes at a one-year follow-up. Bricker et al. (2014) reported that participants with lower AAQ scores during baseline reduced cigarette consumption. Similarly, at baseline, three participants in 2Q had lower AAQ-II scores (i.e., greater acceptance) with two (1, 3) reducing cigarette consumption, one (1) reducing cravings, and one (4) remaining at a similar cigarette consumption rate during post-intervention. However, high acceptance scores may not be necessary for reducing smoking consumption and cravings; or quitting smoking because one participant (5) in 2Q showed no difference in acceptance scores during post-intervention, but

still reduced cigarette consumption and craving rates. Similarly, the one participant in CTQ showed a lower acceptance during post-intervention and was the only participant who quit smoking. Further research that targets acceptance would be valuable in exploring the role of acceptance and smoking cessation.

Commitment

Commitment is another central component of ACT, which is an extension of values, whereby an individual takes responsibility for their actions, and redirects himself toward the values-based purpose (Hayes et al., 2012). This study measured commitment by using the CQSS. Higher scores reflect high commitment while lower scores reflect low commitment.

I did not find *participants with higher scores on the CQSS during post-intervention having better smoking outcomes when compared to CTQ*. The differences between CQSS scores and cigarette consumption rates, and CQSS and cravings to smoke were not statistically significant. In fact, only two out of five participants in 2Q showed increases in CQSS scores during post-intervention, resulting in only one participant (5) reducing cigarette consumption and one participant (4) reducing cravings. The one participant in CTQ did not show higher CQSS scores during post-intervention; however, reduced cigarette consumption during intervention and post-intervention; and quit smoking at F1. A paired sample t-test found that for all participants in 2Q, there was no significant difference between CQSS scores during baseline and post-intervention. In addition, the effect size was small ($d = 0.20$).

Singh (2016) reported that high commitment scores did not necessarily predict successful outcomes and that perhaps, CQSS scores needed to be at a certain level to achieve successful outcomes. Conversely, Kahler et al. (2007) found that higher commitment scores predicted smoking outcomes at post-intervention and had a better chance toward abstinence. Values are linked to commitment (Hayes et al., 2012) so perhaps having unclear values toward quitting smoking affected commitment scores on the CQSS.

Cigarette Dependence

I used the CDS-12 to measure tobacco dependency. Higher scores indicate high cigarette dependence, while lower scores indicate low cigarette dependence. Etter et al. (2003) reported that daily smokers had higher CDS scores than occasional smokers. This is considering that the cut-off score for low cigarette dependence is 12. All participants in this study were daily smokers, having scores above 12; thus, indicating a higher cigarette dependence. This was reflected by 2Q participants' scores ranging between 32 to 56 during baseline and 27 to 55 during post-intervention. The one participant in CTQ score was 56 during baseline and 53 during post-intervention. The differences between CDS-12 scores during baseline and post-intervention were not statistically significant.

An individual analysis reported that two participants (4, 5) in 2Q showed lower dependence during post-intervention. Of the two participants, only one (5) reduced cigarette consumption during post-intervention, while the other (4) did not. The one participant in CTQ had a lower dependence score during post-intervention, reduced cigarette consumption and quit smoking at F1. Interestingly, two participants in 2Q with either higher dependence (participant 1) during post-intervention or the same dependence scores (participant 2) were found to reduced cigarette consumption during post-intervention.

The findings above, provide limited evidence that having lower dependence is related to quitting smoking. Cohen and George (2013) reported that chronic daily smoking leads to dependency and is related to negative reinforcement to escape or avoid an aversive situation. In fact, heavy smokers reported that smoking gives them control over negative moods and cravings, which becomes automatic (Piper et al. 2004). Related to this, participants reported at baseline and follow-up that triggers to smoking were either surgery, or work-related stress. Both factors induce negative affect associated with stressful life events. This reiterates on Elwafi et al. (2013) depiction on positive and negative affect as cues that trigger cravings to

smoke in the addiction loop, and it is these triggers that maintain tobacco addiction and continued tobacco dependence.

Further, motivation and dependence are interrelated to each other because whether a person stops smoking depends on the balance between his/her dependency to cigarettes and the motivation to stop (West, 2004). A criterion for eligibility in this study was participants' motivation to quit smoking. The eligibility survey asked participants if they were motivated to quit smoking using a nominal scale (*yes* and *no*). Motivation is the initial stage for wanting to quit smoking, but smoking success is determined by the degree of cigarette dependence (West, 2004). At follow-up, three participants in 2Q stated they were 'not motivated' to stay smoke-free. The one participant in CTQ reported 'very motivated' to stay smoke-free and was the only one who quit smoking. It is also important to consider that motivation to quit smoking changes with time (West, 2004), making it essential to evaluate psychological and social processes in smoking cessation because both are independent variables in the level of addiction (Etter et al., 2003).

Fidler, Shahab, and West (2010) reported that the measurement of cigarette dependence should predict failure of attempts to stop smoking. The CDS-12 did not predict failure of attempts to stop smoking. Fidler et al. (2010) used a strength of urges to smoke (SUTS) measure and found it to be a good predictor of short-term quitting success in the English population. This measure might be considered in future research.

Cigarette Consumption

This study did not find *ACT-based 2Q more successful in reducing cigarette intake than the mindfulness-based CTQ app*. Four out of the five participants (1, 2, 3, and 5) in 2Q reduced cigarette consumption during post-intervention, while the one participant in CTQ reduced cigarette consumption during post-intervention. With high drop-out rates in CTQ, it did not allow for an effective comparison.

Since acceptance is a central component of ACT, and this framework is integrated in 2Q, I was interested to find out if reduced cigarette consumption would be associated with lower AAQ-II scores (i.e., greater acceptance). There was a strong positive relationship between AAQ-II and cigarette consumption, and this relationship was statistically significant. This suggests that high AAQ-II scores (i.e., low acceptance) is likely to increase cigarette consumption rates. Since four participants reduced smoking consumption regardless of high acceptance scores, it suggests that high acceptance may not be necessary to reduce cigarette consumption rates.

Cravings to Smoke

One of the main concerns people have when they enter a smoking cessation program is cravings to smoke (Gifford et al., 2004). High cravings have been associated with relapse (Killen & Fortmann, 1997). This is considering that abstinence from tobacco leads individuals to experience increase cravings, a motivator to relapse (Shadel et al., 2000), and even in the absence of smoking a cigarette, it can induce cravings because of the associative relationship between smoking and proximal (e.g., the ashtray, the sight of the cigarette) and distal cues (e.g., people who smoke; Conklin et al., 2008; Conklin et al., 2013). One feature that 2Q targets is cravings by encouraging the individual to experience cravings as they come, but not to act on them, and overtime, this helps reduce cravings (2Morrow Inc., 2016a, 2016b). Similarly, CTQ teaches individuals to be mindful about bodily and mental processes when experiencing cravings and allow them to ride them out (Craving to Quit® by Claritas MindSciences, 2018). Over time, this breaks the association between cravings and smoking (Craving to Quit® by Claritas MindSciences, 2018).

This study did not find that *ACT-based 2Q intervention was more successful in reducing the number of cravings to smoke than the mindfulness-based CTQ intervention*. Most participants in 2Q showed variation in craving rates. Only two participants (4 and 5) in

2Q reduced cravings to smoke at post-intervention. For the participant in CTQ, there was a stable pattern with cravings gradually increasing during intervention, then gradually decreasing throughout the course of the program. This perhaps can be explained by Elfawi et al. (2013) that individuals who quit smoking reported reduced cravings several months following quitting, while those who continued to smoke reported higher levels of cravings and increased smoking following intervention.

At face value, there seems to be more evidence supporting 2Q in reducing the number of cravings at post-intervention when compared to CTQ. Statistical methods were used to validate these observed findings. For participants in 2Q, there was a strong positive relationship between AAQ-II and cravings to smoke, but this relationship was not statistically significant. This suggests that higher scores on the AAQ-II (i.e., lower acceptance) increases cravings. Bricker et al. (2014) reported an increase in acceptance in cravings for participants using 2Q (SmartQuit®); however, higher acceptance of cravings was not associated with abstinence during the one-month and two-month follow-up. The ACT component is supposed to encourage participants to accept and experience cravings and allow them to pass by. Singh et al. (2017) found the ACT-component of 2Q helped participants to experience their cravings while not acting on them, and this played a role in reducing cravings over time (13-month period). Perhaps the goal is not to reduce the number of cravings to smoke but to foster readiness to notice and experience cravings to smoke (Forman et al., 2007; Singh, 2016) and in time, cravings will reduce. I speculate that high peaks of cravings during intervention was not due to an increased acceptance of cravings (i.e., most participants in the 2Q intervention had lower scores at baseline), but due to abstinence from smoking cigarettes; however, over time cravings may subside. The follow-up phase in this study did not find conclusive evidence that cravings reduced over time for participants in 2Q; however, for the one participant in CTQ, cravings reduced to an absence at follow-up. It might be correct that cravings do decrease over time (Singh et al., 2017), and utilizing mindfulness-based

strategies were effective in helping this participant quit smoking. Perhaps, if cravings were examined over a longer period like in Singh et al. study, it would be clearer regarding the relationship between cravings and its reductions over time.

Engagement and App Satisfaction

Before starting the intervention, participants were told to select a quit date, and that this could be changed at any time during the program. This allowed participants the flexibility to set their own pace to complete the exercises in each intervention. Participants were also expected to complete a follow-up survey at the one-month and two-month follow-up to help me understand their current smoking status, and to obtain their feedback about the app experience and their smoking outcomes. While not all participants completed the follow-up survey, those who did, reported opening the app between 0-1 times each day and 1-2 times each day (2Q); and 6+ times each day (CTQ). The time spent using the app was very minimal. In Singh's (2016) study, most participants used the app 3 to 20 times a day. It would have been good to get a more accurate analysis from the developers; however, due to time constraints this was not possible and instead relied on self-reports.

Both 2Q and CTQ required participants to complete exercises – eight (2Q) and 22 (CTQ). All participants on both 2Q and CTQ did not complete all the exercises on the given app. Bricker et al. (2017) asserted that quit rates are higher amongst individuals who complete the program. The degree of engagement may not predict successful outcomes despite the fact some participants progressed quite far in the program. For 2Q participants, one participant showed the highest progress rate (91%), did not quit smoking and remained at the same smoking consumption rate during follow-up, while another participant showed a lower progress rate (60%) did not quitting smoking, but reduced smoking during the follow-up phase. However, for four out of five participants, they all reduced smoking consumption during post-intervention. Further, the participant in CTQ, only completed one exercise out of

the 22, and reduced smoking consumption at post-intervention; and quit smoking at the one-month follow-up.

Perhaps features of the app were beneficial to participants' successful outcomes. In fact, Bricker et al. (2014) found that the features of SmartQuit® app were more engaging than the control intervention. Additionally, Bricker et al. (2017) found the new version of SmartQuit® (2.0) more engaging than the older version (1.0) because it was easier to navigate, and clearer for the user to understand what to do because of the design improvement. This study used the newer version. One participant in 2Q reported that there were a few videos liked and thought were positive. Other comments to aspects of the app liked and disliked were the app being confusing to use; and that the app required being fully committed for it to work. There was generally limited feedback to aspects of the app liked and disliked, which if there had been, could have aided understanding of areas that could benefit from improvement. Further, the one participant in CTQ liked the check-in notification reminder and the daily count of cigarettes smoked, which may have helped him quit smoking despite the fact he only completed one out of the 22 exercises on the app. There is no study to my knowledge that has explored the individual features of CTQ, which future research should undertake because this could help understand which features of the CTQ are beneficial for successful smoking outcomes and improve on features least preferred.

The higher retention rates in 2Q intervention suggests that 2Q is slightly more engaging than CTQ. This is considering that both apps have structured activities that are based on evidence-based research on mindfulness and ACT frameworks. Bricker et al. (2017) compared their revised version of the 2Q app to the older version, which provided insight to the level of engagement and discussed the future direction in increasing engagement (e.g., incorporate gaming elements [quiz]) and for future experimental research to identify features of the app that increase engagement). The CTQ features have not been explored, which is

why (as mentioned), understanding which features of the CTQ app could help understand which aspects relate to successful smoking outcomes.

The overall satisfaction of 2Q for two participants reported that they would recommend this app to anyone in the future, while one participant would not recommend this app to anyone in the future. For CTQ, the one participant reported that he would recommend this app to anyone in the future.

Comments

It is noteworthy to mention that both apps were designed for the U.S., English-speaking population, but has benefited people from other Western countries such as New Zealand (Singh et al., 2017). While these apps appeared to be user-friendly for participants in the New Zealand population, it may require adjustments for other populations. Participants in this study were recruited from anywhere in the world so long as they could speak and understand English. These countries included Western countries (U.K., U.S., and New Zealand) and non-Western countries (Dubai and Qatar). One participant (Dubai) commented that the app should improve on being user-friendly. It is to my knowledge that 2Q and CTQ apps have not been studied in non-Western populations. This may have important implications for app developers to assess the cultural appropriateness of the app to the cultural context because the lack of popularity of some of the smoking cessation mHealth apps could be due to cultural inappropriateness (Patel et al., 2015).

Second, the lack of app engagement could be due to poor internet or wi-fi accessibility, restricting participants from gaining the full benefits from accessing the app. It was not a requirement for participants to have internet accessibility but considering internet accessibility in future research will eliminate this factor as a potential cause for low engagement and, thus, might increase engagement.

Third, the generation gap regarding technological competency might result in poor engagement with the app or drop-out rates for individuals who found the app interface difficult to navigate. There were two participants in the 55-64 age group with one who faced difficulty downloading the app, and eventually stopped engaging with the app and with me. An app may be usable by a younger person but difficult for an older person because of different usability needs related to age (Buolos et al., 2014). It is important that app developers match the usability, accessibility and readability (i.e., reading with understanding) of the target audience (Buolos et al., 2014). Perhaps the same study that explores the apps' effectiveness in the older population may help to understand, which aspects of the app are age-appropriate for this population.

Fourth, there were five female participants at the start of the intervention (two in CTQ and three in 2Q). Of the five participants, two remained. Generally, males showed higher retention rates (only one dropped out). Women's concerns about weight may act as a barrier toward smoking cessation because of the fear of gaining weight (Austin & Gortmaker, 2001; Levine et al., 2001; Perkins et al., 2001). Weight concerns become a motivational factor for female cigarette use, resulting in high relapse rates for those who attempt to quit smoking. Perhaps, this is the reason why this study found females had higher cigarette consumption rates than males. It is important to consider that females have different motivation to initiate and maintain tobacco smoking (Abernathy et al., 1995), which has implications for designing strategies for tobacco intervention programs that targets this population.

Fifth, stress may prevent participants from committing to quitting smoking, and in turn, may reflect in their engagement with the app. At follow-up, for one participant's work pressures was a reason for not benefitting enough from the app, and for another participant, she was preparing for surgery. Additionally, one participant sent me a text message to inform that she needed to stop the program at this point because of looking after a friend who was

undergoing surgery. Smoking cigarettes can be a coping mechanism to cope with emotions elicited from stressful life events because nicotine alleviates stress (Choi et al., 2015; Cohen & Lichtenstein, 1990) and reduces anxiety (Pomerleau & Pomerleau, 1991). These apps provided exercises that taught the individual to be in the ‘here and now’ or to be ‘mindful’ about their cravings to smoke; however, regardless of the tools provided, stress may act as a barrier to smoking cessation and potential for relapse (Pomerleau & Pomerleau, 1991).

Sixth, all participants had friends who smoked. Cigarette smoking can have psychosocial functions, such that offering a cigarette can be a means to take a break together with friends or colleagues, which increases bonding (Fagerström, 2011). People serve as distal cues through repeated pairings with smoking, which gains smoking-related associative properties (Conklin et al., 2008; Conklin et al., 2013). In support, Mason et al. (2015) found that readiness to stop smoking was more difficult when more friends smoke. This not only increases cravings to smoke but might trigger individuals to give in to smoking. Dimoff and Sayette (2016) suggested that the social contextual factors should be considered to understand its effect on smoking behaviour. This might have implications for low engagement that this study could not explore.

Strengths

A strength of this study was comparing the effectiveness of two evidence-based smoking cessation apps – ACT-based 2Morrow Quit™ and Craving to Quit®. To my awareness, there has been no study that has compared these two evidence-based apps, which might provide useful information about the effectiveness of both apps in helping to reduce cigarette consumption and cravings to smoke.

Another advantage was recruiting participants from anywhere in the world because it allowed me to see the receptivity of mHealth for smoking cessation and the effectiveness of both apps and whether it helped reduce consumption and craving rates throughout the phases.

To my knowledge, there has been no study on mHealth and smoking cessation using individuals from the Middle Eastern population, which was why accepting participants from this population might provide useful information to the apps' effectiveness. It is noteworthy to mention that since the Eastern Mediterranean region has been projected to increase tobacco prevalence rates in 2025 (WHO, 2018a); therefore, this study could have important implications for mHealth and smoking cessation in this population.

Third, using a single-subject design has several advantages. First, it allowed participants the flexibility to take as long as they needed to complete the intervention. Second, it provided me with feedback based on the data for the relation between the intervention (app) and behaviour change (reduced cigarette consumption and craving rates) over the course of the phases (Nock, Michel, & Photos, 2007). Additionally, the assessments used in this single-subject design allowed me to evaluate and compare individual pattern of behaviour change during all phases.

Since living in a mobile revolution, there has been an increase in mHealth apps, which offers the mobility of accessing the app at one's own convenience (Silva et al., 2015). Both apps were evidence-based and delivered via a smartphone, allowing participants the flexibility and the autonomy to complete the exercises on the app at their own pace. It additionally offered them the platform for the interactivity in teaching and structured exercises to facilitate in smoking cessation.

Limitations

A limitation of this study was the use of measures that collected self-report data. Participants were required to complete questionnaires surrounding smoking behaviour. While self-report is the best information in health behaviours because the information obtained from self-reports can help to understand the attitudes, affect, and behaviours surrounding health behaviours, such as smoking (Stone, Bachrach, Jobe, Kurtzman, & Cain, 2000). Stone et al.

listed some limitations. First, behaviours viewed as maladaptive may be susceptible to socially desirable responses (i.e., a conscious bias to answer based on what one thinks is good), resulting in the person not answering truthfully, especially on sensitive questions; therefore, affecting the accuracy of the self-report data. Second, self-report data is susceptible to recall error when individuals do not provide accurate responses to a question. Third, self-report data does not allow for further information to be collected, which leaves the researcher with questions left unanswered. Fourth, it is unknown as to who completed the questionnaire. Another limitation is the response bias, which is answering in a certain way regardless of the question (Demetriou, Ozer & Essau, 2015). Due to my broad recruitment method, it was not possible for me to be present (i.e., those living outside of my region) when participants filled these questionnaires. Additionally, to ensure consistency of this research, participants from Dubai were also emailed these questionnaires. Being present may have reduced some of these limitations.

Another limitation was the inter-subject variability, which showed individual differences between cigarette and craving rates throughout the phases (small and large differences). While 10 is the minimum number of cigarettes participants smoked, this exceeded up to 30 for some participants. Additionally, craving rates ranged from 0 to 30. Even though participants in this study were homogenous, the differences in cigarette and craving rates throughout the program did not give me a clear direction as to what might be considered an acceptable number of cigarettes and cravings reduced (i.e., magnitude of change). A criterion as to what might be considered an acceptable rate of quitting smoking should be considered, which could help me to clearly relate results according to the criteria level. In other words, including clinical significance in this study could measure how large treatment effects are. Additionally, considering this study was short (approx. 8-months), perhaps examining long-term smoking outcomes (12-months+) could reduce the inter-subject variability. Second, another issue with variability was found in this group comparison studies

even though both groups were homogenous (i.e., smokers). The study's sample size did not reach 20 participants (10 for 2Q and 10 for CTQ) as intended and the CTQ intervention (total = three) experienced a high drop-out rate when compared to the 2Q intervention (total = one). This only allowed me to perform statistical methods on the 2Q group. Even then, the study's sample size was too small to produce significant findings. Bellack, Hersen, and Kazdin (1990) reported that inter-subject variability can be an issue faced with group comparison. Replication is necessary on a larger population to reduce the impact of having low statistical power in the case of drop-out rates, and to reduce inter-subject variability between subjects.

As mentioned, the CTQ intervention experienced high drop-out rates. I speculate that leaving participants on their own to use the app may not be motivating enough for them to check-in and complete the exercises, but perhaps requires a participant-instructor dialogue because there would be more likely for a real social commitment. Brewer et al. (2011) provided individuals with in-person MT and found a greater reduction in cigarette use for those receiving MT, than for those receiving the FFS intervention. Johnson, Aragon, Shaik, and Palmas-Rivas (2000) reported that participants receiving face-to-face learning had more positive perceptions than those who received online learning. This may have implications for this study. Future studies should compare in-person MT and CTQ to confirm this speculation.

Third, this study sought a high number of interested participants ($n = 45$); however, most of them did not pass the prerequisites of this study. I speculate that ownership to an evidence-based app for free would be motivating enough to participate; however, for this study, it might not be the case. Perhaps a monetary incentive or voucher should be considered in future research. Related is participants found it effortful to complete both follow-up surveys, which was displayed by no response even after a follow-up reminder. Bricker et al. (2014) provided participants with a \$25 incentive upon completion of each survey. Perhaps this form of monetary incentive should be considered in future research because getting

participants to complete these surveys could provide invaluable information that might help to understand smoking outcomes and to improve the quality of the apps.

Fourth, there was a limitation in messaging participants once a week to request for craving and cigarette intake rates. Singh et al. (2017) sent participants a text message daily to request for cigarette and craving rates, which might have increased participant motivation due to the perceived support and interaction. This study left participants to use the app at their own pace with minimal researcher-participant interaction. This might provide insufficient support, especially for participants who require more support, which could have motivated them to complete the exercises in the app, remain in the program, and/or facilitated them to quit smoking. It would be good to conduct the same study using both 2Q and CTQ but isolating the two variables – sending participants daily text message vs. once a week text message to see if there is a difference in engagement.

Fifth, the retrospective data could have been clearer regarding cravings. It requested participants to provide an average number of times in the last month where they felt cravings to smoke. It should have been reworded to provide the number of times in the last three days where they felt like a cigarette but did not smoke the cigarette. One participant skipped this question, perhaps because it was difficult to recall how many times cravings were experienced in that month.

Conclusions

This study examined the effectiveness of 2Morrow Quit™ and Craving to Quit® in reducing smoking consumption and craving rates using a single-subject A-B-A2-A3 design. Following post-intervention, there was a small reduction in smoking consumption found in four out of five participants using 2Q and one participant using CTQ. The differences between AAQ-II scores during baseline and post-intervention was not statistically significant, providing no evidence that participants in 2Q would have greater acceptance. Additionally,

the positive relationship between AAQ-II and smoking consumption was statistically significant, suggesting that the acceptance component was not responsible for reducing cigarette consumption since four out of five participants in 2Q reduced cigarette consumption. There was limited evidence that 2Q reduced cravings to smoke during post-intervention as indicated by the observed differences, and statistically verified by the relationship between AAQ-II and cravings to smoke, which found no statistical significance. Again, high acceptance may not be responsible for reduced cravings. High commitment scores did not necessarily predict successful outcomes for participants in 2Q but may have for the one participant in CTQ who showed higher commitment during post-intervention and showed positive smoking outcomes (quit smoking) at follow-up. Lastly, this study supports 2Q as an app of choice with the highest retention rates. Variability in app engagement did not predict successful outcomes with differences in participant progress throughout the program, and no one participant completing all the exercises in both interventions. Overall, both apps seem promising in reducing cigarette consumption rates despite the small reduction seen in this study. Replication of this study is required with a larger sample size to meet the criteria for adequate statistical power.

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Appendix A

Banner

School of Psychology



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

**Make 2018 a Time to Quit
Smoking!**

**2018 is the time of year to make new goals
and one of them could be to quit smoking!**
If you are thinking to quit smoking, are 18
years and over, smoke at least 10 cigarettes
per day, and own a smartphone, then you
may be eligible to participate in my
study. Kindly contact me via email on:
rachel.t026@gmail.com where I will
provide you with further details about this
study.

Appendix B

Information Sheet 1

Information Sheet - Quit Smoking using ACT-Based or Mindfulness-Based Mobile-Health Apps

Dear Participants,

Please take some time to read through this information sheet.

Introduction

My name is Rachel Tan and I am a Master's student at the University of Waikato. I have an interest in mobile health apps and its effect on smoking cravings/urges and cigarette consumption. I would like to invite you to participate in this study.

About this study

This study aims to investigate the effectiveness of two mobile health apps using either acceptance and commitment therapy (ACT; 2Morrow Quit™) or mindfulness techniques (Craving to Quit®) and their ability to reduce smoking craving and cigarette consumption. This will be achieved through six phases. You will be asked to complete some questionnaires, record the number of cigarettes you smoke and cravings you experience during the study, and will be given free access to one of the apps. This study is an extension of Singh, Starkey, and Sargisson's (2017) study who found that SmartQuit™ (now known as 2Morrow Quit™) was highly effective in reducing cravings, and the number of cigarettes smoked. This study expects to find similar results, and would like to strengthen the findings from Singh et al. (2017) by comparing 2Morrow Quit™ app to Craving to Quit® app.

Requirements

The requirements to partake in this study are as follows: (1) participants must be at least 18 years old; (2) smokes at least 10 cigarettes per day in the past 12 months; (3) Not receiving or seeking any psychological treatment for any mental health issues; (4) Own a smart phone

(Android or iPhone); (5) Have a desire/ motivation to quit smoking; 6) Not currently attempting to quit smoking using any other cessation method; and (7) an English speaker

Please complete and submit to the researcher's email, the 'Eligibility Survey' and 'Heaviness of Smoking Index (HSI)' that was sent to you with this information sheet. These questionnaires determine your eligibility in the study. You should hear from the researcher within three working days to notify of your eligibility to participate in this research and next steps. In addition, you should receive another information sheet and consent form. Your participation would be sought for several months, with a time commitment of no more than 10 minutes each day. If you are not eligible to participate, you will receive an email advising you of this.

Best regards,

Researcher:

Rachel Tan

Department of Psychology

University of Waikato

Email: rachel.t026@gmail.com

Below are the details of my supervisor and the University Human Research Ethics Committee (HREC Health) if you require further information to this research.

Supervisor:

Dr. Rebecca Sargisson

School of Psychology

University of Waikato

Email: rebecca.sargisson@waikato.ac.nz

University Human Research Ethics Committee (HREC) (Health):

This research project has been approved by the Human Research Ethics Committee of the University of Waikato under HREC (Health) #2018–06. Any questions about the ethical conduct of this research may be addressed to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Appendix C

Information Sheet 2

Information Sheet - Quit Smoking using ACT-Based or Mindfulness-Based Mobile-

Health Apps

Introduction

My name is Rachel Tan and I am a Master's student at the University of Waikato. I have an interest in mobile health apps and their effect on smoking cravings/urges and cigarette consumption. This study aims to investigate the effectiveness of two evidence-based mobile health apps using either acceptance and commitment therapy (ACT; 2Morrow Quit™) or mindfulness techniques (Craving to Quit®) and their ability to reduce smoking craving and cigarette consumption in 20 individuals. You will be randomly assigned by chance to either app.

What will be required of you:

This study will consist of six parts:

1. You will be sent questionnaires that will collect your demographics, nicotine dependence, smoking behaviours, and your commitment to quit smoking. In addition, if you choose to (a) record information about the number of cigarettes you smoked each day, and the cravings/urges experienced each day, this would be required for a period of 3 to 5 days. Alternatively, if you choose (b) to complete a retrospective questionnaire about smoking patterns, this will be emailed to you.
2. If you choose to (a) record information about the number of cigarettes you smoked each day, and the cravings/urges experienced each day for a period of 3 to 5 days, the researcher will be sending you a daily text message to remind you to please send the number of cigarettes smoked and the number of cravings/urges experienced each day.
3. Once you have (a) recorded information about the number of cigarettes you smoked each day, and the cravings/urges experienced each day for a period of 3 to 5 days, or (b) completed the retrospective survey, you will be randomly assigned by chance to either the 2Morrow Quit™ or Craving to Quit® program. You will be emailed instructions to download either app free of charge. You are advised to read the terms

and conditions of the app before you begin. The App will collect personal information from you including name, email and other demographic information, which will be shared with the researcher and the app owner. This program will prompt you to complete a quit plan, complete daily exercises and choose a quit date that can be changed at any time.

4. When you have reached your quit date, you will be asked to record the number of cigarettes smoked and the number of cravings/urges experienced each day for the following 3 to 5 days. Additionally, you will be re-administered three questionnaires that will collect nicotine dependence, smoking behaviours, and commitment to quit smoking.
5. One month later, the researcher will ask you to complete a follow-up survey to assess your smoking status and your satisfaction with the app you were assigned to. This will be repeated one month later.
6. Upon completion of this study, you will be sent an information sheet providing you with a range of interventions including medications available to support you to quit smoking.

Your data

This research will respect your confidentiality by omitting your name, but instead your name will be coded and attached to the collected data. This avoids any trace to you. The information collected for the study's purpose will be stored securely in an anonymised format and your names (if known) will not be stored in the same file. Once the thesis has been submitted, all data will be provided to the researcher's supervisor, Dr. Sargisson, who will retain the data in a University, password-protected server for a minimum of 5 years. The findings from this study will be submitted as a written report as part of the requirement for my Master's thesis, and be made available at the School of Psychology office. A summary of the findings will be sent to your email at the end of the project. The data may also be used in future research outputs such as journal articles or conference presentations.

The right to withdraw

Your participation is entirely voluntary, therefore, if you should change your mind about participating in this study, then you have the right to withdraw at any time without penalty without giving any reason(s). Participants who wish to withdraw are required to notify the researcher about their withdrawal via email.

You are free at any point to decide to use other interventions and/or medications (e.g., nicotine replacement products) but this would end your participation in this study as it does not meet the eligibility requirement.

Next Step

If this study sounds interesting to you and you would like to participate, then contact the researcher via email.

Best regards,

Researcher:

Rachel Tan

Department of Psychology

University of Waikato

Email: rachel.t026@gmail.com

Below are the details of the researcher's supervisor and the Human Research Ethics Committee (HREC Health) if you require further information to this research.

Supervisor:

Dr. Rebecca Sargisson

School of Psychology

University of Waikato

Email: rebecca.sargisson@waikato.ac.nz

University Human Research Ethics Committee (HREC) (Health):

This research project has been approved by the Human Research Ethics Committee of the University of Waikato under HREC (Health) #2018-06. Any questions about the ethical conduct of this research may be addressed to the Secretary of the Committee, email humanethics@waikato.ac.nz, postal address, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Appendix D

Eligibility Survey

Thank you for your interest to participate in this smoking cessation study. Please fill out the following questions to determine eligibility to participate in this study.

1. What is the best number to reach you?
2. What is the best email address to reach you?
3. Can you speak and understand English?
Yes No
4. How old are you?
5. Do you have access to a smartphone?
Yes No
6. Are you currently seeking or undergoing psychological treatment?
Yes No
7. Are you currently using medication or an intervention (e.g., nicotine replacement products) to quit smoking?
Yes No
8. Do you have a psychotic or affective disorder?
Yes No
9. What other form of tobacco did you use in the last 30 days? (Check all that apply)
 - Cigars or cigarillos
 - Pipes
 - Pinch or snuff
 - Chewing tobacco ○ Snus ○ Biddis or kreteks
 - Waterpipe, hookahs, sheesha (with nicotine)
 - E-cigarettes (if using with e-juice, nicotine)
 - Other, please specify:
10. How many cigarettes do you smoke in a day in the past 12 months?
0-10 11-20 21-30 31+
11. Do you currently have the desire to quit smoking in the near future?
Yes No

Appendix E

Consent Form

Research Project: Quit Smoking using ACT- or Mindfulness-Based Mobile-Health Apps

Please complete the following checklist. Tick (✓) the appropriate box for each point.	YES	NO
1. I confirm that I have read and understand the information sheet for the above study.		
2. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.		
3. I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.		
4. I understand that my participation is voluntary and that I am free to withdraw at any time, up to two weeks after completing the app without giving any reason, and without any penalty.		
5. I understand that relevant sections of data collected during the study may be looked at by myself and supervisor from the University of Waikato and that your name will be kept anonymous. I give permission for these individuals to have access to my data.		
6. I understand that data collected will be used by either 2Morrow Quit™ and Craving to Quit® depending on which app I am assigned to. I acknowledge that it is my responsibility to read the <i>Terms and Conditions</i> on the app I am assigned to.		
7. I understand that the researcher may have access to the data collected by the app to monitor my progress while using the app.		
8. I understand that my participation is confidential and that no material, which could identify me personally will be used in any reports on this study.		
9. I understand that the information supplied by me could be used in future academic publications.		
10. I agree not to use any other interventions or medications (e.g., nicotine replacement products) during all phases of this study.		
11. I understand that I have the right to decline participation at any time or phases during the study.		
12. I would like to have a copy of the summary findings emailed to me at the end of the project.		

Email address:		
13. I agree to take part in the above study.		

Declaration by participant:

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the Chair of the University Human Research Ethics Committee: humanethics@waikato.ac.nz

Participant's name (Please print):

Signature: _____ Date: _____

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it. I believe that the participant understands the study and has given informed consent to participate.

Researcher's name (Please print):

Signature: _____ Date: _____

Appendix F

The Heaviness of Smoking Index (HSI)

The heaviness of smoking index consists of FTND item 1 and item 4, using the same response scales and calculating the total score using the sum on those two items.

- 1) How soon after you wake up do you smoke your first cigarette?
 - a) Within 5 minutes
 - b) 5-30 minutes
 - c) 31-60 minutes
 - d) 60+ minutes

- 2) How many cigarettes do you smoke?
 - a) 10 or less
 - b) 11-20
 - c) 21-30
 - d) 31 or more

Appendix G

Acceptance and Action Questionnaire

Below you will find a list of statements. Please rate how true each statement is for you by circling a number next to it. Use the scale below to make your choice.

1 – Never true, 2 – Very seldom true, 3 – Seldom true, 4 – Sometimes true,

5 – Frequently true, 6 – Almost always true, 7 – Always true

1) My painful experiences and memories make it difficult for me to live a life that I would value.

1 2 3 4 5 6 7

2) I'm afraid of my feelings.

1 2 3 4 5 6 7

3) I worry about not being able to control my worries and feelings.

1 2 3 4 5 6 7

4) My painful memories prevent me from having a fulfilling life.

1 2 3 4 5 6 7

5) Emotions cause problems in my life.

1 2 3 4 5 6 7

6) It seems like most people are handling their lives better than I am.

1 2 3 4 5 6 7

7) Worries get in the way of my success.

1 2 3 4 5 6 7

Appendix H**Commitment to Quitting Smoking Scale**

Below you will find a list of statements. Please rate how true each statement is for you by circling a number next to it. Use the scale below to make your choice.

1 – Strongly disagree, 2 – Disagree

3 – Neither disagree nor agree, 4 – Agree,

5 – Strongly agree

1) I am willing to put up with whatever discomfort I have to in order to quit smoking.

1 2 3 4 5

2) No matter how difficult it may be. I won't let myself smoke once I quit.

1 2 3 4 5

3) Feeling very anxious or restless won't prevent me from quitting smoking.

1 2 3 4 5

4) Even if I really want one. I won't let myself pick up a cigarette once I quit.

1 2 3 4 5

5) No matter how much I crave a cigarette when I quit. I'm going to resist the urge to smoke.

1 2 3 4 5

6) Feeling very depressed or sad won't prevent me from quitting smoking.

1 2 3 4 5

7) I'm not going to let anything get in the way of my quitting smoking.

1 2 3 4 5

8) Feeling very angry and irritable won't prevent me from quitting smoking.

1 2 3 4 5

Appendix I

The Cigarette Dependence Scale

Below you will find a list of statements. Please circle the response that applies to you.

- 1) Please rate your addiction on a scale of 0-100
 I am NOT addicted at all=0
 I am extremely addicted to cigarettes=100
 - a) 0 – 20
 - b) 21 – 40
 - c) 41 – 60
 - d) 61 – 80
 - e) 81 – 100

- 2) On average, how many cigarettes do you smoke per day, based on the last 12 months?

0 – 5	6 – 10
11 – 20	21 – 29
30+	

- 3) Usually, how soon after waking up do you smoke your first cigarette, based on the last 12 months?

0-5 minutes	6-15 minutes
16-30 minutes	31-60 minutes
61+ minutes	

- 4) For you, quitting smoking would be:

Impossible	Very difficult
Fairly difficult	Fairly easy
Very easy	

Please indicate whether you agree with each of the following statements:

- 5) After a few hours without smoking, I feel an irresistible urge to smoke

Totally disagree	Somewhat disagree
Neither agree or disagree	Somewhat agree

Fully agree

- 6) The idea of not having any cigarettes causes me stress

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 7) Before going out, I always make sure that I have cigarettes with me

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 8) I am a prisoner of cigarettes

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 9) I smoke too much

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 10) Sometimes I drop everything to go buy cigarettes

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 11) I smoke all the time

Totally disagree Somewhat disagree

Neither agree or disagree Somewhat agree

Fully agree

- 12) I smoke despite the risks to my health

Totally disagree Somewhat disagree
Neither agree or disagree Somewhat agree Fully agree

Appendix J**Non-Eligibility Email**

Dear Participant,

Thank you for your interest in my study. However, I am not seeking further participants so your participation is not required at this time. I encourage you to engage with the app yourself if you wish to reduce your cigarette intake.

Best regards,

Rachel Tan

Appendix K**Demographics Questionnaire**

1. What is your age?
18-24 years old
25-34 years old
35-44 years old
45-54 years old
55-64 years old
65-74 years old
75 years or older
2. What is your gender?
Male Female
3. Please specify your ethnicity (or race)?
European/Caucasion
Emirati or Arab
Hispanic or Latin
Black or African American
Asian / Pacific Islander
Indian
Other_____
4. What is the highest level of school you have completed or the highest degree you have received?
Less than high school degree
High school degree or equivalent (e.g., GED)
Some college but no degree
Associate degree
Bachelor degree
Graduate degree
5. Does anyone in your household smoke?
Yes No
6. If answered yes, please circle the option that applies to you
Children Partner/husband Flatmates

Other_____

7. Do you have friends that smoke?

Yes No

8. How many cigarettes do you smoke per day?

9. How many years have you been a cigarette smoker?

0-1 1-2 2-3 3-4 4-5 5-6 6+

10. Have you tried to quit before?

Yes No

11. Were you successful?

Yes No

12. How many times did you try to quit?

13. What methods did you use to quit?

Cold turkey Nicotine replacement Quitline Herbs/supplements

E-cigarette Medication Hypnosis Acupuncture

Other_____

Appendix L**Retrospective Questionnaire**

1. How old were you when you first started to smoke regularly?
 - 0 – 12
 - 13 – 18
 - 19 – 22
 - 23 – 30
 - 31 – 40
 - 50+

2. Have you attempted to quit smoking before? Yes No

3. If yes, what methods did you use to aid in smoking cessation?
 - Cold Turkey
 - Nicotine Replacement Therapy
 - Behaviour Therapy
 - Counselling
 - Other _____

4. If yes, how many attempts have you made to quit smoking in the past? _____

5. In the last month, how many cigarettes did you smoke daily? _____

6. In the last month, did you set a daily limit in the number of cigarettes you smoked daily? Yes No

If Yes, how many cigarettes did you smoke daily? _____

7. In the last month, were there occasions where you felt like you should not smoke?

Yes No

If yes, how often did you experience this weekly?

1 2 3 4 5 6 7 8 9 10 11

8. In the last month, what time of the day did you smoke most?

Morning Afternoon Evening Late night

9. On occasions when you told yourself that you should not smoke, what is the likelihood that you went ahead and smoke?

(never) 1 2 3 4 5 6 7 8 9 10 (always)

10. What were the triggers that made you want to smoke?

Stress

Friends/peers/family

Social settings where smoking is permitted (bars, restaurants)

Other _

11. How often did you refrain from smoking to keep your smoking rate down?

Never Less than once per day 1-2 times per day 3-10 times per day

More than 10 times per day

Appendix M

Follow-up Survey

1. My smoking status:
I quit I did not quit
2. The app helped me to quit smoking? YES NO
3. How many cigarettes have you smoked daily in the last month? _____
4. The app has helped me reduced the number of cigarettes smoked?
YES NO
5. If your answer is "Yes" for Q. 4., please specify how many
0-1 1-2 2-3 3-4 5-6 6+
6. If you haven't already quit smoking, do you intend to reduce the number of cigarettes?
 - Yes, within the next month
 - Yes, within the next 6 months
 - Yes, sometime in the future but not in the next six months
 - No, not planning to reduce smoking
7. The app helped me with my urges or cravings to smoke?
Strongly disagree Disagree
Neutral Agree
Strongly agree
8. I still experience cravings to smoke? YES NO
If your answer is "Yes" for Q. 8., how often do you experience this weekly?
0-2 2-4 4-6 6-8 8-10 10+
9. If your answer is "Yes" for Q. 8., how often do you experience this weekly?
0-2 2-4 4-6 6-8 8-10 10+
10. How strong are those urges? **NOT strong** 1 2 3 4 5 6 7 8 9 10 **VERY strong**
11. Were there any other form of tobacco you used in the last 30 days? (Check all that apply)
 - Cigars or cigarillos
 - Pipes
 - Pinch or snuff
 - Chewing tobacco o Snus o Biddis or kreteks
 - Waterpipe, hookahs, sheesha (with nicotine)

- E-cigarettes (if using with e-juice, nicotine)
- Other, please specify: _____
- None of the above

12. I reset my quit date? YES NO

13. If you answered yes for Q. 12., how many times did you reset your quit date?

0-1 1-2 2-3 3-4 5-6 6+

14. How satisfied are you with the app?

NOT satisfied 1 2 3 4 5 6 7 8 9 10 **VERY satisfied**

15. How satisfied are you with your progress in quitting smoking at this time?

NOT satisfied 1 2 3 4 5 6 7 8 9 10 **VERY satisfied**

16. On a scale of 1 to 10, rate how confident you are that that you can stay smoke-free.

NOT at all confident 1 2 3 4 5 6 7 8 9 10 **VERY confident**

17. How would you rate your motivation today to stop smoking cigarettes?

Not motivated at all Somewhat motivated Very motivated

18. Since starting the app, what situations have triggered cravings/urges? (Check all that apply)

- People smoking around me
- Drinking alcohol
- Drinking caffeine
- Easy to get
- Work-related stress
- Lack of support
- Other _____

19. How many times on average did you open the app each day?

0-1 1-2 2-3 3-4 5-6 6+

20. How many times on average did you open the app each week?

0-1 1-2 2-3 3-4 5-6 6+

21. Can you briefly describe an aspect/s of the app you liked?

22. Can you briefly describe an aspect/s of the app you disliked?

23. Can you identify **TWO things** you think are the most effective aspects of the app that helped you to reduce or quit smoking?
24. Do you think the app has room for improvement?
Strongly agree agree
Disagree strongly disagree
25. If you agreed with the above, can you describe where _____
26. Would you recommend this program to anyone in the future? YES NO

Appendix N

Treatments to Quit Smoking

Dear Participant,

I thank you for participating in this study.

To further support you to quit smoking, I have provided you with a list of interventions and medications, which I hope you find useful in helping you to quit smoking. It is highly recommended you talk with your health care provider before you start any nicotine replacement, prescription or complementary therapies to ensure your health and safety.

1. Nicotine replacement therapy (NRT)

A medically approved way to take nicotine by other means than tobacco, helps to reduce cravings associated with abstaining from smoking, and decreases the chances of smoking. These are available from most pharmacies. Please seek your healthcare provider if you are interested in NRT options.

These include:

- Nicotine gum.
- Nicotine trans-dermal patch.
- Nicotine lozenges
- Nicotine nasal spray/inhaler

2. Prescription Options

Prescription options may help you with the craving to smoke, withdrawal symptoms, and/or abstain from starting tobacco again. Please seek your healthcare provider if you are interested in prescription options.

- Bupropion SR (Zyban)
- Varenicline (Chantix)

3. Behaviour Therapies

These evidence-based treatments will support you to identify specific aims/goals, focus on the present, and teach you strategies to deal with cravings and withdrawal symptoms.

- Acceptance and Commitment Therapy

- Cognitive Behaviour Therapy
- Relapse prevention therapy

4. Telephone Counselling

This service provides you with the information (and advice) and support toward the goal of quitting smoking. Check your government directory to find the services available to you.

Once again, I thank you for participating in this study. I wish you all the best on your journey to quit smoking.

Best regards,

Rachel Tan

Appendix O

Reminder Text Message

Hi _____,

I've noticed you haven't accessed the app for 7 days. Just a reminder to continue to use the app to help you on your journey to quit smoking.

Appendix P

The Addictive Loop

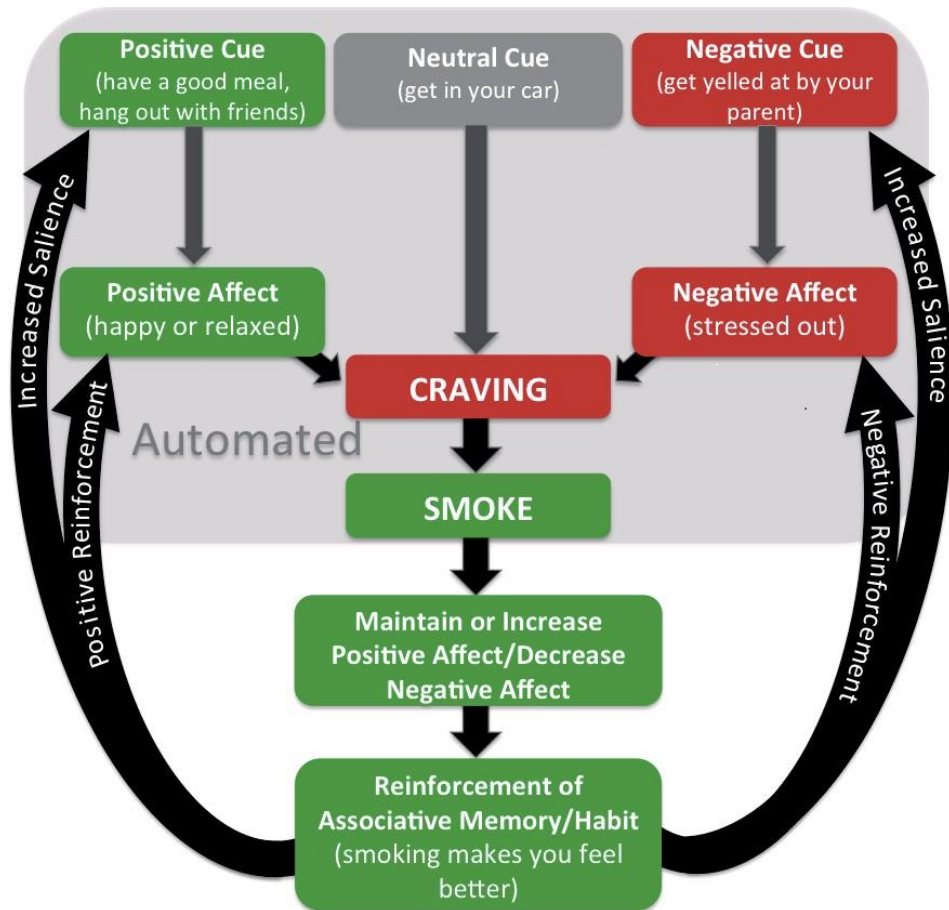


Figure 8. The addictive loop is formed either with positive, neutral, or negative affective states and its association with smoking. This acts as cues that triggers cravings to smoke (Pbert & Judson Brewer, 2017).

Appendix Q

App Features

2Morrow Quit™

Table 7

A Description of the Features of 2Morrow Quit™

Core Themes	Information	Key Steps
Awareness/Being in the Present	Awareness of the here and now, experienced with openness. Even if that includes unhelpful (or unpleasant) thoughts, feelings, urges, or sensations.	1. Create a quit plan. This helps the customize a program for the individual wanting to quit smoking.
Acceptance/Willingness	Allowing experiences, emotions, and thoughts to come and go without fighting them.	2. Daily exercises 8 lessons on 8 separate days Practice exercises and record urges to smoke. The urge monster helps the individual to learn new ways to deal with urges.
Self as Context	Accessing a transcendent sense of self. (You are more than your thoughts, emotions, feelings, actions, etc.).	3. Receive customized messages and reminders.
Cognitive Defusion	Methods used to lessen the impact of cognitive content – such as thoughts or memories – when it interferes with the experience of present reality or desired action.	4. Access any-time coaching This provides the user with options: (1) awareness; (2) having an urge; (3) If I slip; (4) Motivation; (5) stories; (6) tips for success; (7) social; and (8) ask a coach
Values	Discovering what is most important and motivating to one's true self.	5. Earn a certificate at the end of completion.
Committed Action	Setting goals according to values and taking healthy steps to achieve those value-based goals.	6. Maintained and relapse support. This provides the user with up to 6-months support so that the individual

can continue their journey to abstain
from smoking

Note. Adapted from 2Morrow Inc. (2016a) and 2Morrow Inc. (2016b).

Craving to Quit®

Table 8

A Description of the Modules and Contents of Craving to Quit®

Module	Contents
1	Introduces the Craving to Quit program and mindfulness, introduces habit formation using an animation, and provides a guided mindful smoking exercise.
2	Setting personalized goals, e.g., list three reasons why you want to quit smoking, and provides a mindful smoking exercise.
3	Teaches body scan meditation, provides a guided body scan exercise, and provides a mindful smoking exercise.
4	Teaches how to work with cues, affective states, and craving using RAIN, and provides a RAIN exercise.
5	Introduces the concept of craving using an animation with the metaphor of craving as a tantrum toddler, i.e., let the toddler cry it out, and provides a RAIN exercise.
6	Teaches how to recognize triggers, e.g., list some of your triggers, and provides a RAIN exercise.
7	Expands on the concept of craving using an animation with the metaphor of craving as a fire, i.e., let the fire burn out, and provides a RAIN exercise.
8	Teaches how to use noting practice, i.e., the “N” of RAIN, in everyday life, and provides a noting practice exercise.
9	Teaches strategies for staying on track, and provides a noting exercise.
10	(Un)resistance Training, and provides a noting exercise.
11	Builds on noting practice by teaching curiosity, a core element of mindfulness, and provides a curiosity exercise.
12	Expands on the concept of craving and curiosity using an animation with the metaphor of a hot coal, asks “What do you get from smoking mindfully today?” Teaches loving kindness meditation, provides a loving kindness exercise, and provides “Wild Geese” by Mary Oliver.

- 14 Teaches evaluating the costs & benefits of smoking, provides a loving kindness exercise.
- 15 Misperceptions about Quitting, tell a smoking buddy you are quitting today
- 16 Builds on noting and curiosity by teaching noting while walking meditation, provides a walking noting practice.
- 17 Teaches open awareness of thoughts, to work mindfully with thoughts that trigger smoking, using animations such as “Thoughts like a Radio.”
- 18 Builds on walking while noting with animations such as “Tripping on Thoughts,” “Autobiography in 5 short chapters” by Portia Nelson, provides a noting exercise.
- 19 Asks subjects to reflect on their own experience with treatment to gather evidence for how treatment helps with smoking cessation, noting practice with a particular eye out for doubt.
- 20 Provides tips on staying motivated and maintaining mindfulness practice, subjects write down a mantra to use and set mantra reminder.
- 21 Quit day ceremony, subjects tell a friend or family member that today is their quit day.
- 22 Incorporates mindfulness practices as a new, healthy habit, and instructs the user on which modules to return to if they relapse.
- Bonus “Big Mind Meditation” audio by Joseph Goldstein; Tree Analogy for reinforcing noting video; Attitude is Everything video; “Mountain Meditation” audio by Joseph Goldstein; Sitting Meditation audio

Note. Reprinted from Garrison, Pal, Rojiani, Dallery, O’Malley, and Brewer (2015).