

**Factors associated with adherence to an e-health ecological momentary  
assessment protocol in distressed young people.**

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## Table of Contents

Table of Contents.....	2
Table of Figures & Tables .....	7
Abstract.....	8
Declaration.....	9
Acknowledgements.....	10
Introduction.....	11
Overview of mental-health in young people.....	11
Mental-health interventions in young people .....	11
Mental-health prevention and help-seeking concerns in young people .....	12
Traditional mental-health assessments and their limitations.....	13
Ecological Momentary Assessments .....	13
EMA delivery through technology: e-health .....	14
EMA items for self-monitoring of symptoms .....	14
Benefits of EMA.....	15
Adherence .....	16
Adherence to EMA .....	16
Factors predicting adherence to e-health .....	17
Personal factors as predictors of adherence to EMA.....	18
Personality and the Big Five .....	18
The influence of personality on adherence.....	19
Motivation.....	20

Self-Determination Theory in healthcare .....	22
Habit theory, habit-formation and cues .....	22
Associative cues .....	23
The present study .....	24
Aims.....	24
Hypotheses.....	25
Research setup .....	26
Methods.....	27
Study design and procedures .....	27
Baseline: The ReachOut study .....	28
Follow-up: The present study .....	28
Participants.....	29
EMA protocol .....	31
Measures: Baseline .....	34
Socio-demographics .....	34
Personality .....	34
Psychological distress.....	35
Measures: Follow-up .....	35
Adherence.....	35
Motivation .....	36
Automaticity.....	38

Cues .....	38
Open-ended questions.....	38
Data analysis .....	39
Assumption tests.....	40
Data-driven variable selection .....	41
Aim 1: Non-linear regression analysis .....	41
Aim 2: Linear regression analysis .....	43
Aim 3: Qualitative analysis .....	44
Power analysis .....	44
Results.....	45
Descriptive statistics .....	45
Identification of predictors.....	47
Variable selection .....	47
Analysis of variance .....	49
Aim 1: Who did and did not adhere to the EMA.....	49
Regression: Zero-inflated negative binomial .....	49
Aim 2: Why individuals adhered to the EMA .....	51
Regression: Linear hierarchical .....	51
Interaction effects and exploration of cues.....	53
Aim 3: Barriers, facilitators and experiences.....	53
Motivational intent .....	53

Expectations.....	54
Expectations met.....	58
Facilitators .....	59
Barriers .....	59
Suggestions.....	60
Discussion.....	61
Summary of results and implications.....	61
Aim 1: Individual differences – personality and demographics.....	62
Aim 2: Motivation and habit-formation .....	63
Aim 3: Barriers, facilitators and experiences .....	65
Limitations and strengths .....	66
Future research directions .....	68
Conclusion .....	70
References.....	72
Appendix 1: Baseline Questionnaire .....	94
Appendix 2: EMA Protocol Instructions .....	100
Appendix 3: Follow-up Email .....	101
Appendix 4: Follow-up Questionnaire.....	102
Appendix 5: Non-adherence Follow-up Questionnaire .....	107
Appendix 6: Power Analysis .....	109
Appendix 7: Comparison of Means across Tertiles.....	110

Appendix 8: Assumption Tests..... 113

Appendix 9: SPSS Regression Command Syntax ..... 116

    Linear Hierarchical Multiple Regression..... 116

    Non-Linear Zero-Inflated Negative Binomial ..... 116

## Table of Figures & Tables

Figure 1. Self-Determination Theory.....	21
Figure 2. Study design .....	27
Figure 3. Participant recruitment and sampling flow.....	31
Figure 4. Primary EMA questions .....	32
Figure 5. Supplementary EMA questions.....	33
Figure 6. Histogram of EMA entries per participant .....	41
Figure 7. Histogram of EMA entries per participant (with non-adherence group) .....	42
Figure 8. Comparison of ‘expectations met’ across tertiles and score distribution .....	58
Table 1. Socio-demographic characteristics of participants .....	30
Table 2. List of selected Intrinsic Motivation Index items per subscale .....	37
Table 3. Descriptive statistics of baseline study measures with group comparisons.....	45
Table 4. Descriptive statistics of study measures for follow-up participants .....	46
Table 5. Pearson correlation matrix for all baseline variables.....	48
Table 6. Pearson correlation matrix for additional follow-up measures.....	48
Table 7. Zero-Inflated Negative Binomial model parameters (N=130) .....	50
Table 8. Results of hierarchical regression models predicting adherence (n=46).....	51
Table 9. Regression model from step 2 - coefficients predicting adherence (n=46).....	52
Table 10. Thematic analysis with responder illustrative quotes.....	55
Table 11. Tukey HSD comparison for ‘expectations met’ .....	59

## Abstract

**Background.** Monitoring mental-health symptoms in young people informs early interventions and promotes positive long-term health outcomes. One promising e-health methodology that enables such monitoring is Ecological Momentary Assessment (EMA), which captures everyday mood fluctuations and other mental-health symptoms in natural settings. However, low adherence rates threaten the efficacy of EMA. This study aimed to explore practically relevant factors that reveal who adheres to EMA protocols and possible reasons why.

**Methods.** Young people ( $N=130$ , 16-27 years) were previously recruited from the ReachOut mental-health support website. Of the 65 who commenced a recommended 14-day EMA protocol, 49 (75.4%) responded to this follow-up study. Individual differences of personality and demographics, and two theoretically proposed predictors of adherence – motivational orientation and habit-formation – were examined using a mixed methods approach.

**Results.** Participants in the EMA protocol were younger and reported lower stress and anxiety. The most efficient model ( $F(9, 36)=2.93, p=.01$ ) explained 42.3% of the variance in adherence to EMA. Identifying with the integrated form of *extrinsic* motivation and an agreeable personality significantly predicted adherence ( $B=3.01, p=.009$  and  $B=1.28, p=.029$  respectively). Participants indicated that they valued and were interested in the EMA, however, repetitiveness of EMA items and forgetfulness inhibited adherence.

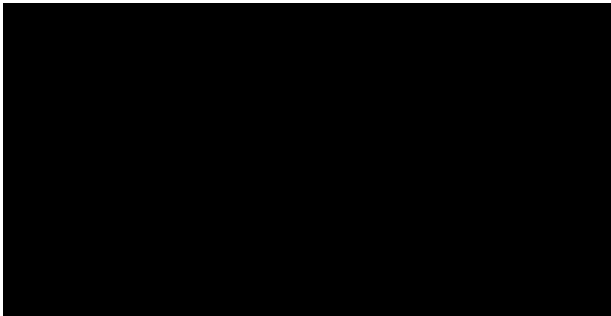
**Conclusions.** The results distinguish who might adhere to and benefit from EMA, although additional research is required to characterise non-adherence. To realise the potential of EMA in managing young people's mental-health, this study informs e-health design strategies that might improve adherence by bringing attention to aspects of motivational theory.



## **Declaration**

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the School to restrict access for a period of time.



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## **Overview of mental-health in young people**

The reciprocal interplay between biological, psychosocial and environmental factors often influences thoughts, emotions and behaviours (Bandura, 1999). These responses are not only sources of pleasure and purpose, but may be sources of distress and dysfunction. In Australia, one in four young people encounter common mental-health conditions, broadly characterised as anxiety-related and mood dysregulation or depressive disorders (ABS, 2015). The transitional period from adolescence through to young adulthood (16-24 years), in particular, brings about vulnerabilities that increase the risk of developing such disorders (Cummings, Caporino, & Kendall, 2014). In the wider 10-24 year age group, mental-health disorders account for almost 45% of the total worldwide disease burden (Gore et al., 2011). Predictably, these disorders have well-recognised adverse effects on emotional, social, physical, and educational outcomes in young people (Kendall et al., 2010; Strauss & Breier, 1987). Similar consequences are associated with ‘sub-threshold’ mental-health issues, which are equally, if not more, prevalent than clinically diagnosed conditions (Judd et al., 1998). Thus, mental ill-health, specifically in young people, constitutes a major public health challenge and contributes to substantial personal hardship.

### *Mental-health interventions in young people*

Early life mental-health problems display a chronic and episodic course, leading to recurrent mental-health disorders in adulthood if undetected or untreated (Letcher, Sanson, Smart, & Toumbourou, 2012). Anxiety in adolescence, for instance, results in a 2 to 3-fold increased likelihood of anxiety-related disorders in adults (Pine, Cohen, Gurley, Brook, & Ma, 1998). Similarly, three-quarters of young people who experience at least one major depressive episode endure multiple episodes over their lifetime (Keller & Boland, 1998). Notably though, depression exists on a scale from mild to major, with certain symptoms –

including low energy levels (fatigue), lack of sleep and increased appetite – appearing in a prodromal or initial phase when observing the progressive development of depressive episodes (Fava & Tossani, 2007; Young, Watel, Lahmeyer, & Eastman, 1991). Longitudinal studies in adolescents support this notion by revealing that even sleep complaints predict depressive disorders in adulthood better than traditional assessments (Dekker et al., 2007; van Lang, Ferdinand, & Verhulst, 2006). With most adult mental-health problems emerging before 24 years of age (Kessler et al., 2005), monitoring and detecting symptoms early in the course of these pervasive disorders offers a possible first step in preventing them from becoming established.

#### *Mental-health prevention and help-seeking concerns in young people*

Fortunately, preventive efforts, that bring together assessments followed by effective early interventions, demonstrate positive improvements in the mental-health and functioning of young people (e.g. Webb, Kauer, Ozer, Haller, & Sancu, 2016). A comprehensive review of randomised controlled trials confirms that preventive practices lower the incidence of depression by up to 21%, irrespective of the type of prevention employed (van Zoonen et al., 2014). Nevertheless, the stigma often attached to mental-illness is strongly associated with young people's reluctance to seek help for emotional problems (Anderson & Lowen, 2010; Rickwood, Deane, & Wilson, 2007). In Australia, only 31.2% of young women, and even fewer young men, 13.2%, seek professional assistance when experiencing mental-health difficulties (Slade et al., 2009). Instead of seeking help, many adolescents prefer to solve their own problems (Andrews, 1999). Therefore, although practical opportunities to assess mental-health problems have proven difficult, self-help, that incorporates self-monitoring, may present a feasible alternative.

### *Traditional mental-health assessments and their limitations*

Notwithstanding, traditional mental-health assessments continue to rely almost entirely on retrospective questionnaires and semi-structured interviews (Calinoiu & McClellan, 2004; Ebner-Priemer & Trull, 2009). Yet, the ability to recall behavioural and emotional symptoms during such assessments is limited by memory inaccuracies over time, and further subject to systemic biases or personal heuristics (Johnson, Hashtroudi, & Lindsay, 1993; Tversky & Kahneman, 1974). Conversely, mental ill-health is often characterised by intense mood states that regularly fluctuate in response to emotional and environmental stimuli (Linehan, 1993). This temporal instability is difficult to detect with traditional assessments that require participants to recall and aggregate experiences over the past week or month (Ebner-Priemer & Trull, 2009; Solhan, Trull, Jahng, & Wood, 2009). As a result, important details and opportunities for early interventions may be overlooked by standard retrospective assessment methods, which provide neither sufficient access to fluctuations in subjective experiences nor insight into the context of socio-environmental influences.

### **Ecological Momentary Assessments**

One promising methodology that captures day-to-day fluctuations in symptoms associated with mental-health and may overcome limitations in traditional assessments is Ecological Momentary Assessment (EMA; Stone & Shiffman, 1994). EMA borrows from time-sampling techniques employed in observational studies, and extends the well-validated Experience Sampling Method (ESM), which has been applied across the social sciences for some time (Csikszentmihalyi & Larson, 2014). The rationale behind EMA, according to Shiffman, Stone, and Hufford (2008), is: to avoid memory problems and bias associated with retrospective self-reports; to achieve ecological validity; and, to enable the study of dynamic processes over time. By repeatedly asking simple questions, such as “*how are you feeling today?*”, under the influence of day-to-day dynamics, these assessments are considered

*ecologically* valid because they occur within the context of an individual's natural environment. EMA provides self-reports of real-time behaviour, subjective experiences and mood, encompassing specific *moments* in everyday life. As such, EMA addresses issues of recall and memory bias while incorporating dynamic situational factors (Ebner-Priemer & Trull, 2009; Shiffman et al., 2008; Solhan et al., 2009).

#### *EMA delivery through technology: e-health*

Recording and capturing data using electronic means is another important contemporary aspect of the EMA methodology. Given that internet access and smartphones have become ubiquitous and routine in the lives of young people (Rideout, 2016), delivering EMA electronically – referred to as *e-health* – seems inevitable and more likely to appeal to young people. Indeed, recent studies demonstrate the efficacy and viability of e-health EMA usage in real-world trials. For example, Hetrick et al. (2017) describe the feasibility of an EMA tool to monitor depressive symptoms in young people, which, in turn, significantly improved both Personal Health Questionnaire-9 (PHQ-9) and measures of suicidal ideation over time. Similarly, another smartphone-based EMA displayed greater sensitivity to changes in depressive symptoms that went otherwise undetected using pen-and-paper means (Moore, Depp, Wetherell, & Lenze, 2016). These findings are supported by Kim et al. (2016), who showed that daily EMA mental-health ratings achieve classification accuracies (AUC=0.72-0.85) comparable to more traditional depression assessments (e.g. PHQ-9). In general, e-health approaches deliver mental-health assessments to young people in more accessible and timely ways, promoting the open disclosure of sensitive information (Bradford & Rickwood, 2015).

#### *EMA items for self-monitoring of symptoms*

There are few restrictions on the type of questions or items permissible within EMA. Some EMA items capture environmental or contextual conditions, others assess real-time

health symptoms; including their onset, progression and potential relapse (Torous, Staples, & Onnela, 2015). One example, a unitary self-monitoring EMA item known as a Visual Analogue Mood Scale (VAMS), uses ‘happy’ and ‘sad’ as anchors on a sliding scale. This simple item significantly predicts relapse in depression over a 5-year period (van Rijsbergen, Bockting, Berking, Koeter, & Schene, 2012); even outperforming structured clinical interviews. The authors later concluded that studies should incorporate repeated assessments to enhance early detection of relapse (van Rijsbergen et al., 2014). More recently, Place et al. (2017) established that certain EMA behavioural indicators, including mood, fatigue, social connectedness and anhedonia successfully predicted depressive symptoms such that both patients and clinicians could potentially intervene. Thus, self-monitoring using validated EMA items is ideally suited to take advantage of the warnings presented by early-phase symptoms of mental-health.

### *Benefits of EMA*

Self-monitoring of health behaviours is also associated with a measurable reactive effect, which results in beneficial behaviour change under certain conditions, such as positive valence and the desire to achieve goals (e.g. Kazdin, 1974). A review of 22 studies found strong associations between self-tracking of diet, exercise, or weight, and weight loss (Burke, Wang, & Sevick, 2011). Significant reductions in Post-Traumatic Stress Disorder (PTSD) symptoms were also observed through the reactive effects from self-monitoring of stressful episodes (Tarrier, Sommerfield, Reynolds, & Pilgrim, 1999). Most relevantly though, self-monitoring of mood using EMA has been shown to increase emotional self-awareness (medium-large effect sizes) and subsequently reduce depressive symptoms in adolescents (Kauer et al., 2012; Reid et al., 2011). Stated otherwise, the mere act of self-monitoring, using EMA methodologies, triggers reactive effects that may reduce symptoms associated with mental-health disorders. As outlined, EMA demonstrates potential across the spectrum

of mental-health management; from effectively assessing individuals, through to self-monitoring that might lead to detection and even prediction of mental-health symptoms. When used as a means of self-management and to inform just-in-time adaptive interventions (JITAI), EMA extends practically into the preventive space as an adjunct to traditional approaches that might reduce the mental-health burden in young people (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002; Heron & Smyth, 2010; Nahum-Shani et al., 2016).

### **Adherence**

However, for all its promise, EMA is not without limitation. Although the repetitiveness of EMA provides valuable insight into behaviours and subjective states, the consensus is that it imposes an inherent burden on participants that reduces overall adherence (Bolger, Davis, & Rafaeli, 2003). In health, adherence is defined as the “*extent to which a person’s behaviour ... corresponds with agreed recommendations*” (WHO, 2003). Recently, Kim et al. (2016) specifically established empirical support for the critical role of adherence in the accuracy of self-monitoring. A large body of evidence indicates that adherence is the key link between process and outcomes and is important for the effectiveness of e-health interventions in general (Perski, Blandford, West, & Michie, 2016). Whilst some adherence challenges confronting EMA – for example, forgetfulness – are shared with other e-health interventions, many are unique (Christensen, Griffiths, & Farrer, 2009). Thus, it is crucial to examine adherence in relation to highly burdensome EMA protocols.

#### *Adherence to EMA*

Reported rates of adherence to EMA are mixed, with variation across areas of study, modes of administration, and types of sampling used. For example, Reid et al. (2009) describe the completion of 76% of a possible 504 EMA entries over an intensive 7-day study of adolescents using a smartphone mood monitoring program. Moderate adherence was also



seen by Moore et al. (2016), with 72% of participants recording 3 daily assessments over a 10-day period. Crosby et al. (2009) observed even more moderate 14-day EMA compliance rates of 67.7% while collecting negative affect ratings in 130 participants despite offering a US\$200 incentive. In contrast, a larger online trial conducted in the general Dutch population ( $n=12,503$ ) found that only 40% completed sufficient assessments over a 30-day period to allow for accurate statistical analysis (van der Krieke et al., 2016). Similarly, markedly low engagement rates of only 18% (5/28 daily recordings completed) were noted in a study capturing mood states from 208 young people (Kenny, Dooley, & Fitzgerald, 2016).

Interestingly though, Burke et al. (2017), along with other recent studies, report a positive willingness from participants to use e-health to self-manage mental-health issues (e.g. Firth et al., 2016; Harrison et al., 2011) – indicative of the growing acceptability of e-health. Despite this trend, researchers suggest that a ‘law of attrition’ exists, whereby e-health usage begins high and declines over time (Eysenbach, 2005). For example, an EMA study that gathered self-reports of sleep patterns, saw adherence drop from 80% down to 13.3% over a 90-day period (Min et al., 2014). For EMA to be effective therefore, it must exert minimal burden whilst adequately addressing and maintaining adherence over time. Determining the factors associated with adherence to EMA is a first step in achieving this.

#### *Factors predicting adherence to e-health*

Research on adherence in e-health, however, has uncovered few significant determinants. In a review of 20 studies that reported adherence to web-based interventions for psychosis (Killikelly, He, Reeder, & Wykes, 2017): most studies did not specifically analyse predictors; two studies found male gender and young age to predict non-adherence; and others found no such relationship. Similarly, another review by Christensen et al. (2009) noted that demographic variables, such as age, socioeconomic status, education, and marital status, typically did not predict adherence to online interventions of anxiety and depression.

More specifically, a recent review of 42 unique EMA studies attempted to elucidate factors associated with adherence to EMA, but emphasised only the study design factors of EMA protocols, such as study length, technology, sampling methods and reminder frequencies (Wen, Schneider, Stone, & Spruijt-Metz, 2017). With many studies reporting adherence rates lower than 70%, Wen et al. (2017) called for a need to identify additional factors that may impact young people's adherence to EMA.

### *Personal factors as predictors of adherence to EMA*

Previous studies addressing adherence to e-health have adopted persuasive design paradigms, which are influenced by classic learning and behavioural change theories that focus on extrinsic motivational elements; for example, reinforcements, rewards, social support and incentives (Fogg, 2009; Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012). One such study presented a systematic attempt to address adherence during a 12-month EMA protocol, resulting in promising adherence rates of 87.4% on items of mood and environmental context (Burke et al., 2017). Notably though, Donovan and Blake (1992) propose, and have since reinforced, that adherence is a result of rational or reasoned decisions made by individuals based on their personal and social circumstances (see also Donovan, 2009). In the context of e-health, there is renewed interest, therefore, in personal factors that affect individuals' self-regulation – that is, their capacity to not only initiate but also maintain or adhere to changes in behaviours. Surprisingly though, little is still known about how individual differences influence adherence in relation to the use of e-health tools, specifically within the context of highly burdensome EMA protocols.

### **Personality and the Big Five**

Individual differences, particularly personality traits, play one role in shaping people's behaviours (Bronfenbrenner & Morris). Personality is defined as “*enduring dispositions that*

*prompt distinctive patterns of interaction with one's environment*" (Olver & Mooradian, 2003). Whereas, personality traits themselves refer to characteristic, persistent patterns of thought and emotion that are stable over time and explain behaviour across different situations (Costa & McCrae, 1992a). The most accepted model of personality is the five-factor model (FFM), the Big Five, which groups similar traits (Costa & McCrae, 1992a). The Big Five *factors* – openness, conscientiousness, extraversion, agreeableness, and neuroticism – claim to represent the basic structure underlying human behaviour and preferences, providing a framework and parsimonious classification in the psychology of individual differences. In terms of traits, of most interest, conscientiousness is linked to consistency of behaviour, a desire to seek achievements and pursue long-term goals; agreeableness relates to compliance, meeting expectations and being cooperative; and, neuroticism measures the tendency to experience mood swings and emotions (Digman, 1990).

#### *The influence of personality on adherence*

A substantial body of research has shown that personality traits correlate with many behaviours and aspects of life (Paunonen, 2003), yet limited research exists on the influence of personality on adherence behaviours. One recent small study in adolescents' willingness to undergo orthodontic treatments indicated that agreeableness demonstrates positive correlations with adherence to many treatment modalities, while neuroticism exhibits a negative association (Hansen, Liu, Schrader, Dean, & Stewart, 2013). This is consistent with earlier findings looking at adherence to chronic disease medication in an adult population ( $n=749$ ) which found that both agreeableness and conscientiousness were significantly positively related to adherence and that low adherence was related to higher scores in neuroticism (Axelsson, Brink, Lundgren, & Lotvall, 2011). Other personality traits have not been shown to be consistently related to adherence.

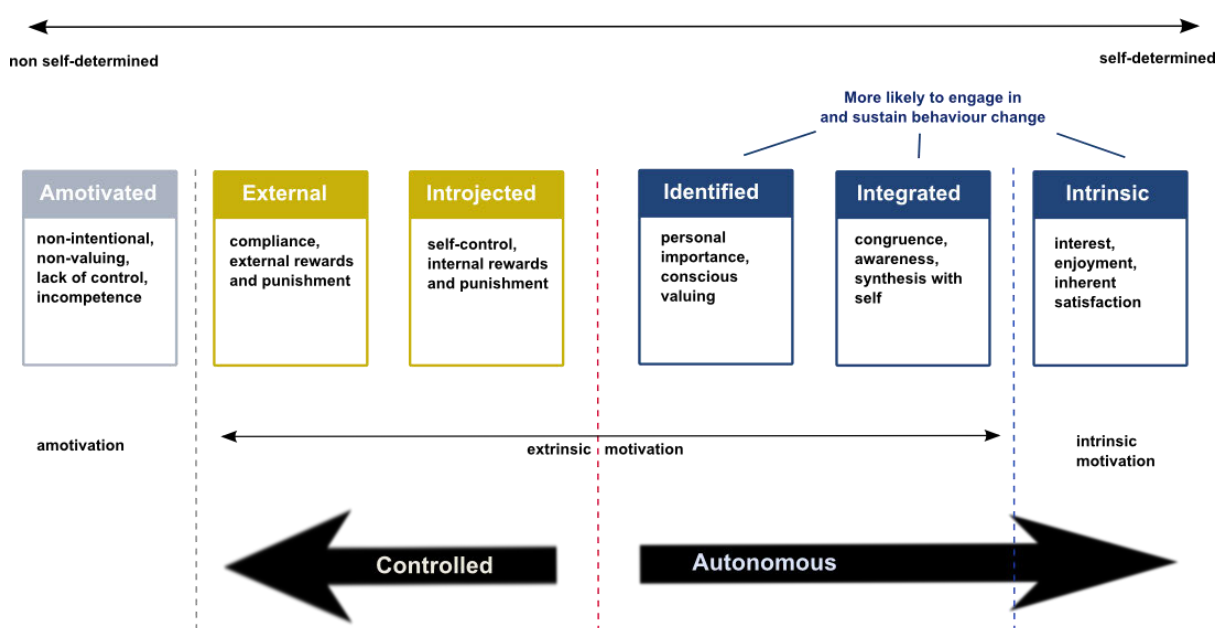
Several studies have found personality traits to be predictive of both technology adoption and internet-use behaviour (Amichai-Hamburger, 2002; Devaraj, Easley, & Crant, 2008), though few studies have extended this to e-health. Rhode (2011) outlined a theoretical framework of personality aspects that are relevant to personalised health monitoring; describing the potential influence of personality on adherence. Similarly, Rahman (2017) more recently described a research model that incorporates the influence of the Five Factors of personality on a patient's intention to use healthcare technology. Yet, no known studies have empirically investigated the relationship between personality and e-health adherence.

### **Motivation**

There is, however, some criticism of the sensitivity of trait-based individual difference constructs, such as personality, to consider them appropriate explanatory determinants of behaviour. For instance, in research on the influence of personality traits on medication adherence, Axelsson et al. (2011) point out the inadequacies of personality factors alone as predictors of behaviour; suggesting that actions adapt to social and environmental situations or cognitive states. This view aligns with Social Cognitive Theory (SCT; Bandura, 1999), which describes people as agentic operators, and proposes that the most influential structures are located within the 'self', not in behavioural expressions of fixed traits. Bandura (1999) was highly critical of a factor analysis of global personality traits, instead advocating for the greater explanatory and predictive importance of *dynamic* personal factors as processes that regulate behaviour and indeed motivation.

Motivation relates to decisions that involve how, when, and why individuals allocate effort towards a specific behaviour (Parks-Leduc & Guay, 2009). A review of the evidence base for health technologies found the widespread use, but limited effectiveness, of attempts to increase motivation to engage individuals in certain behaviours (Mohr, Schueller,

Montague, Burns, & Rashidi, 2014). Indeed, most behavioural theories treat motivation as a unitary construct – for example SCT (Bandura, 1999), the Theory of Planned Behaviour (Ajzen, 2002) and, to some extent, the Fogg Behavioural Model (Fogg, 2009) – however, Self-Determination Theory (SDT; Deci & Ryan, 1985) distinguishes between different orientations or types of motivation as predictors of underlying self-regulated behaviours. The theory suggests that not only the degree of motivation but also motivational orientation affects engagement and maintenance of behaviour (Figure 1. Self-Determination Theory). The most basic distinction is between *intrinsic* motivation, or willingly acting out of interest or enjoyment; and *extrinsic* motivation, which refers to pursuing an independent outcome, including forms of instrumental or supporting value (Ryan & Deci, 2000).



**Figure 1.** *Self-Determination Theory*

*SDT proposes that motivation varies in the degree to which it is autonomous or controlled.*

*A highly autonomous, or self-determined, form of **extrinsic** motivation is regulated through identification (**identified** regulation), where individuals identify with the personal importance of a behaviour. Further to this, the most autonomous form of extrinsic motivation is **integrated** regulation, which occurs when behavioural changes have been fully assimilated by the individual. This occurs through self-examination and bringing new actions into congruence with values and needs. **Intrinsic** motivation represents the most autonomous form of regulation (Ryan & Deci, 2000).*

To achieve intrinsic motivation, people must experience satisfaction of the needs both for competence and – more importantly in the context of self-monitoring behaviour – autonomy, which refers to the freedom to make decisions about behaviours (Deci & Ryan, 1985). Not surprisingly then, in studies of motivational orientations as predictors of behaviour, more autonomous motivation is associated with greater engagement in classrooms (Reeve, Jang, Carrell, Jeon, & Barch, 2004), better performance (Miserandino, 1996), less dropouts from school (Vallerand & Blssonnette, 1992), and even improved health and psychological well-being (Sheldon & Kasser, 1995). In contrast, external regulation is often associated with lower engagement and lower quality of behaviour, or only doing the minimum (Ryan & Deci, 2006). It is important to note that behaviour change is more effective and sustained when individuals are autonomously motivated (Ryan & Deci, 2006).

#### *Self-Determination Theory in healthcare*

SDT, as a macro-theory of human motivation, was initially applied to education and employment settings, but is now being adopted in healthcare (Deci & Ryan, 2012; Williams, Grow, Freedman, Ryan, & Deci, 1996). A recent large-scale meta-analysis of SDT studies in healthcare contexts examined the relations between psychological need satisfaction and autonomous motivation to beneficial health outcome; concluding that SDT is a viable conceptual framework to study antecedents and outcomes of motivation for health-related behaviours (Ng et al., 2012). According to Ng et al. (2012), SDT views lack of engagement in health behaviours as primarily a problem with motivation, such that increased motivation – particularly, of the autonomous forms – directly leads to increases in behavioural adherence.

#### **Habit theory, habit-formation and cues**

Habit Theory recognises that certain behaviours, once established, may be moderated by more implicit, non-conscious processes (Gardner, 2015; Rebar et al., 2016). For instance,

Carroll and Bandura (1990) assert that repetition of competent behaviour no longer requires higher cognitive control, instead, it becomes automated or habitual. Although research suggests that repetition is necessary for habits to develop in the first place, Verplanken (2006) argue that the primary measure of habit strength is the *automaticity* of the behaviour. Automaticity is defined by a lack of conscious awareness or intent whilst engaging in habitual behaviour (Lally & Gardner, 2013). Expressed otherwise, individuals engage in habitual behaviour in the absence of motivation, and when control over behaviour is primarily stimulated by environmental cues (Verplanken, Aarts, van Knippenberg, & Moonen, 1998). This implies that adherence may be moderated by factors other than individual differences and self-determination, such as those that influence the automaticity of behaviour – repetition and cues. Despite the repetitive nature of EMA, to the author's knowledge, no studies have explored automaticity within EMA protocols. Previous research has, however, shown that habit-formation was the strongest predictor of adherence to medication-taking, explaining up to 27% of the incremental variance in adherence (Alison Phillips, Leventhal, & Leventhal, 2013). Similarly, habitual behaviour is widely seen as a possible mechanism for the maintenance of adherence to health behaviours and has been shown to moderate the intention-behaviour relationship i.e. motivation (Rothman, Sheeran, & Wood, 2009).

#### *Associative cues*

As mentioned, habits can be characterised not only by repetition and automaticity but by their tendency to be triggered by cues in the context and environment of everyday life (Orbell & Verplanken, 2010; Wood & Neal, 2007). According to Habit Theory, there are at least five noted categories of associative or contextual cues – time of day, the presence of other people, location, emotional state, and the immediately preceding behaviour, activity or routine (Pimm et al., 2016) – that might account for the moderating effect of automaticity.

This is an important practical consideration when exploring adherence, because the reminders emanating from the EMA technology act as simple cue mechanisms based on classic behaviour theory. It is plausible though that environmentally contextual cues may exert a more dominant effect over the timing and effectiveness of such reminders, and therefore are worth exploring.

### **The present study**

Given the issue of non-adherence to e-health EMA and limited research into the possible contribution of individual differences, including self-determination and habit-formation, this study investigates practically relevant factors predicting participant adherence to a 14-day EMA protocol. As part of a previous study, a purposeful sample was recruited from visitors to the ReachOut website, which supports young people who are experiencing the early onset of symptoms of mental-health problems (Metcalf & Blake, 2014). Poor adherence (<50%) to the recommended 14-day EMA protocol intervention was noted, and became the pretext for the present study – a secondary prospective analysis (or follow-up) of participants. In addition to psychological distress, the focus of this study is on several explanatory domains: individual differences of personality; self-determination factors of motivation; the moderating effects of habit-formation (automaticity); and, the presence of possible habit-forming contextual cues.

#### *Aims*

The broad aims of the current research, therefore, are three-fold. First, to determine *who* did and did not adhere to an EMA protocol, this study considers baseline demographics, psychological distress, and, more importantly, personality; as indicators of individual differences. Second, as a follow-up to the first aim, this study examines *why* participants adhere to an EMA protocol by understanding underlying motivational orientation; extending



this to investigate possible moderators of motivation such as habitual behaviours and their associative cues. Last, this study qualitatively explores *why* participants did and did not adhere to an EMA protocol by identifying barriers, facilitators and experiences using open-ended questions.

### *Hypotheses*

Although the present study is mostly exploratory in nature, there is an attempt to prepare hypotheses concerning the identified factors that may predict adherence to EMA. In relation to individual differences of personality, and based on findings in behavioural research on adherence, this study makes the tentative hypothesis (H1) that:

*Conscientiousness (H1a) and agreeableness (H1b) are positively associated, and neuroticism (H1c) is negatively associated with observed measures of adherence to EMA.*

No hypotheses were advanced for the other Big Five personality factors – openness to experience, and extraversion – due to a lack of previously reported correlations with adherence.

The present study is informed within the framework of SDT, and, to the author's knowledge, is the first to investigate motivational orientation as possible personal psychological factors that might predict adherence to EMA. Considering that the satisfaction of basic psychological needs facilitates autonomous self-regulation comprising both intrinsically motivated behaviour and well-internalised extrinsic motivations (Deci & Ryan, 2000), this study makes the logical hypothesis (H2) that:

*Intrinsic motivation, interest-enjoyment (H2a), and autonomous forms of extrinsic motivation, value-usefulness (H2b), are positively associated with adherence to EMA.*

No hypotheses are developed in relation to controlled forms of extrinsic motivation as this was not the focus of the present EMA protocol.

Finally, since automaticity has been shown to moderate the intention-behaviour relationship i.e. motivation and, therefore, in keeping with previous research and Habit Theory (Gardner & Lally, 2013; Rothman et al., 2009), the present study proposes the hypothesis (H3) that:

*Automaticity will moderate the association between motivation and adherence – specifically, that the association between motivation and adherence will be weaker for those who report high levels of automaticity with EMA.*

No specific hypothesis is made in relation to the exploration of the presence of contextual cues.

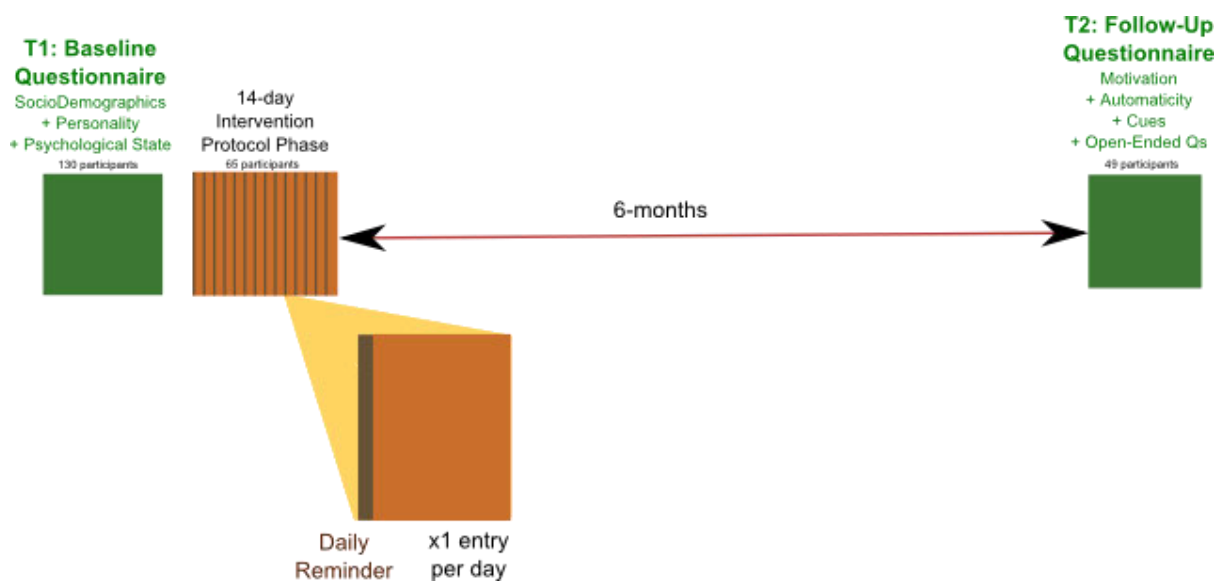
#### *Research setup*

To address the stated aims, this study adopts a mixed methods approach. Quantitative data, was obtained using standard validated questionnaires both at baseline and at a 6-month follow-up after the 14-day EMA protocol. The data is explored to initially identify predictive variables of interest and subsequently to test the study hypotheses. A thematic analysis is undertaken to investigate the third qualitative research aim and provide a richer assessment of participant's adherence behaviours and experiences in relation to the EMA.

## Methods

### Study design and procedures

This prospective exploratory study forms part of a broader research program focusing on the effectiveness of self-monitoring using smartphones and personal devices to examine health trajectories in young people. At *baseline* (T1), an earlier study – the ReachOut study – conducted initial participant recruitment, administered a multiple-measures questionnaire, and then invited participants to take part in a 14-day online *intervention protocol* – the Ecological Momentary Assessment (EMA) activity. Participants from the original study were asked to complete a 6-month *follow-up* measure as part of the present study (T2, Figure 2. Study design).



**Figure 2.** Study design

A timeline showing the baseline questionnaire (T1), the 14-day intervention protocol (EMA) and the final follow-up questionnaire at 6-months (T2) as part of the present study. Participants were prompted to record one online EMA entry on each day of the intervention protocol phase – a minimum of 14 entries in total to complete the protocol.

*Baseline: The ReachOut study*

The ReachOut study asked participants for key demographics: gender, age, education, and employment – then administered a battery<sup>1</sup> of self-report questions (Appendix 1: Baseline Questionnaire). Participants were also emailed a link to optionally register and take part in the online *EMA protocol*. Instructions prompted participants to self-report mood, sleep, exercise and diet every day over a 14-day period. A \$20 voucher for completion of at least 8-days of data and a personalised health report were offered as incentives (Appendix 2: EMA Protocol Instructions).

*Follow-up: The present study*

As part of the present follow-up study, all participants who opted to take part in the EMA activity, were emailed at 6-months (Appendix 3: Follow-up Email). This ‘EMA protocol group’ received a link to an online questionnaire, which asked questions on motivation, in addition to automaticity and habit-forming cues in relation to the EMA. Open-ended questions were included to further explore barriers, facilitators and experiences related to the EMA activity. This questionnaire took approximately 10 minutes to complete (Appendix 4: Follow-up Questionnaire). A random sample of participants ( $n=12$ ) who opted *not* to take part in the EMA, the ‘non-adherence group’, were also emailed at follow-up and offered an alternative follow-up questionnaire<sup>2</sup>. This shorter questionnaire consisted of only open-ended questions, which took approximately 5 minutes to complete (Appendix 5: Non-adherence Follow-up Questionnaire). A \$20 voucher incentive was offered for completion of either follow-up questionnaire to honour the ReachOut study incentive.

A mixed-method analysis was carried out to address the three stated aims:

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<sup>1</sup> Only personality and psychological distress measures were selected for inclusion in the present study.

<sup>2</sup> This sample size was selected to allow saturation to be reached accounting for moderate response rates.

1. A quantitative retrospective exploration of *who* did and did not adhere to the EMA using measures from the baseline ReachOut study questionnaire.
2. A quantitative prospective exploration examining *why* participants adhered to the EMA using measures from the follow-up questionnaire.
3. A prospective thematic analysis of *why* participants did and did not adhere to the EMA using open-ended questions as part of the follow-up questionnaire.

All procedures in this study were approved by the Flinders University Social and Behavioural Research Ethics Committee (SBREC No.7022-6). Questionnaire data collection was managed using Qualtrics (2013) software.

## **Participants**

At baseline, the previous ReachOut study used online convenience sampling over a six-week period to recruit 130 young adults aged 16.17–27.25 years ( $M_{\text{age}}=21.01$ ,  $SD=2.48$ , 90.8% female) via popup advertisements when visiting reachout.com.au<sup>3</sup>. Participants voluntarily agreed to continue and be contacted for the present follow-up study. No exclusion criteria were applied.

Of the 65 (50% [65/130]) baseline participants included in the ‘EMA protocol’ group, forty-nine (75.4% [49/65]) young people aged 16.5-27.3 years (93.9% female) responded to the follow-up questionnaire. The participants were mostly students (63.3%) or in part-time employment (20.4%). Most participants (65.3%) had completed a higher education qualification (Diploma, Certificate, Degree or higher) and the remainder had at least completed high school (34.7%). In terms of socio-demographic characteristics, this ‘EMA

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<sup>3</sup> ReachOut Australia operate the www.reachout.com website – one of the most widely accessed mental-health services in Australia – supporting young adults experiencing distress, refer Metcalf and Blake (2014).

protocol follow-up' group appeared representative of the total ReachOut study sample, since no comparative differences were noted (Table 1).

**Table 1.**  
*Socio-demographic characteristics of participants*

Characteristic	Total sample	Subsample	Proportional difference z-test
	ReachOut study (N=130)	EMA follow-up subsample (n=49)	z unless otherwise indicated
<i>Participants</i>			
Age in years M (SD)	21.01 (2.48)	20.76 (2.45)	0.71 <sup>†</sup>
Age range	16.17 - 27.25	16.5 - 27.25	-
<i>Gender % (n)</i>			
Female	90.8 (118)	93.9 (46)	0.8
Male	7.0 (9)	4.1 (2)	0.8
Other	2.2 (3)	2.0 (1)	0.1
<i>Highest Education % (n)</i>			
Post-Graduate	1.5 (2)	0.0 (0)	-
Degree	25.4 (33)	32.7 (16)	1.2
Cert or Diploma	28.5 (37)	32.7 (16)	0.7
High School	43.8 (57)	34.7 (17)	1.3
Refused	0.8 (1)	0.0 (0)	-
<i>Activity or employment % (n)</i>			
Full-time	13.1 (17)	8.2 (4)	1.0
Part-time	22.3 (29)	20.4 (10)	0.3
Student	55.4 (72)	63.3 (31)	1.1
Other	9.2 (12)	8.2 (4)	0.2

<sup>†</sup> one-sample z-test

From the remaining 65 'non-adherence group' baseline participants, twelve (6 male, 6 female) were selected at random after stratification by gender to balance the inclusion of men and women. The response rate to the alternative follow-up questionnaire of open-ended questions was moderate (50% [6/12]), with only 6 complete replies (66.7% female). See Figure 3 for the participant recruitment and sampling flow.

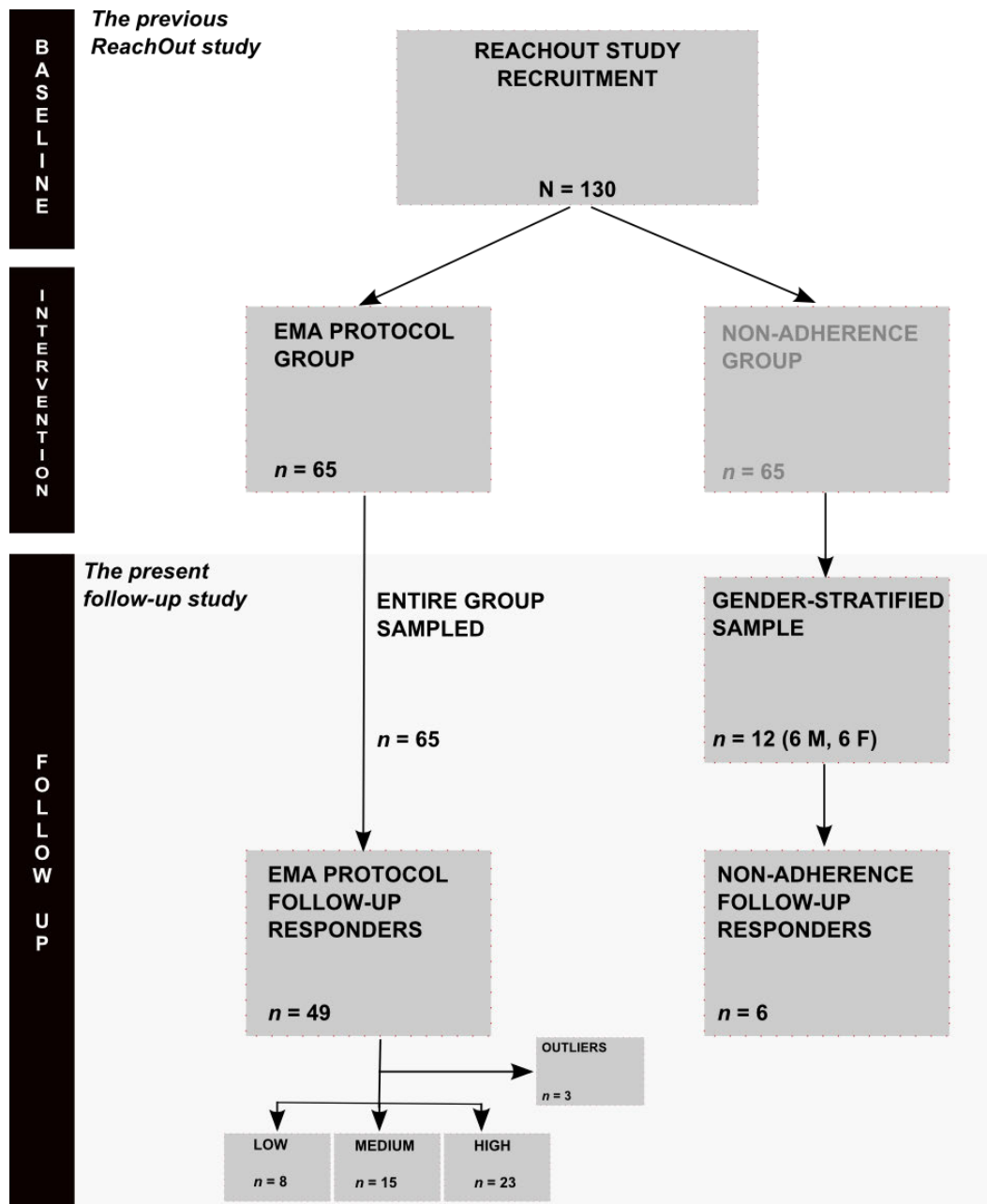


Figure 3. Participant recruitment and sampling flow

## EMA protocol

A custom version of the goAct (2016) online tool, an e-health technology platform for secure data collection, delivered the EMA protocol. The online tool was accessed on personal computers or mobile phone devices via any standard web browser connected to the Internet.

Reminder messages containing a login link to this online tool were sent as daily emails at a time of each participant's choosing (default 9 a.m.). Participants subjectively rated three daily components of momentary emotional experience – *mood* (“How are you feeling today?”), *energy* (“How is your energy today?”) and *sleep quality* (“How well did you sleep last night?”). The instructions asked participants to move a slider ‘face’ to report each of the three items on one-dimensional scales from 1-100 (Figure 4).

The screenshot displays the REACH OUT.COM interface. At the top, the logo 'REACH OUT.COM' is shown in a blue box. Below it, a dark grey banner says 'Welcome John!'. The main content area is titled 'Move faces to match ...' and contains three horizontal sliders, each with a question and a face icon on a scale:

- Question 1:** 'How are you **feeling** today?' (yellow icon). The scale ranges from 'very low' to 'great', with 'ok' in the middle. A yellow face icon is positioned at the 'ok' mark.
- Question 2:** 'How is your **energy** today?' (green icon). The scale ranges from 'very tired' to 'very energetic', with 'ok' in the middle. A green face icon is positioned at the 'ok' mark.
- Question 3:** 'How well did you **sleep** last night?' (blue icon). The scale ranges from 'very poorly' to 'very well', with 'ok' in the middle. A blue face icon is positioned at the 'ok' mark.


**Figure 4.** Primary EMA questions

*Text labels presented on the slider indicate comparative ranges e.g. very low, very poorly, very tired to great, very energetic and very well.*



Participants were also able to enter supplementary details about the previous day – specifically their sleep times, physical activity (minutes of both vigorous and mild/moderate exercise), servings of fruit and vegetable intake, and alcohol consumption (Figure 5).


Complete the following questions ...


 **Sleeping Time**


Start


End


hours


 How long did you engage in **MILD / MODERATE exercise** yesterday?


e.g.



 How long did you engage in **VIGOROUS exercise** yesterday?


e.g.



 How many serves of **fruits and vegetables** did you have yesterday?  
(if you are unsure what counts as 1 serving, click [HERE](#))


  
x None


  
x 1 - 2 serves


  
x 3 - 4 serves


  
x 5+ serves

 How much **alcohol** did you consume yesterday?

  
x None

  
x 1 - 2 std drink

  
x 3 - 4 std drink

  
x 5+ std drink

[Next](#)

**Figure 5.** Supplementary EMA questions

## Measures: Baseline

### *Socio-demographics*

Recorded and relevant demographic factors included: gender (male, female or other), and age, which was calculated from each participant's date of birth.

### *Personality*

The BFI-10 (Rammstedt & John, 2007), a short-form of the standard 44-item Big Five Inventory (BFI-44; John, Donahue, & Kentle, 1991), assesses dispositional traits defined by the Five Factor Model/Theory of Personality (Costa & McCrae, 1992a). Participants were asked "How well do the statements describe your personality...?". Responses to 10 items<sup>4</sup> such as *I see myself as someone who...is reserved, ...is relaxed and ...is generally trusting*, were measured on a 5-point Likert scale (from *Disagree strongly*=1, to *Agree strongly*=5) and scored across the Big Five *factors* – openness, conscientiousness, extraversion, agreeableness, and neuroticism. The BFI-10 assigns two items per factor, one keyed positive and one negative.

The authors of the BFI-10 demonstrate good test-retest reliability, convergent validity (with the Neuroticism-Extraversion-Openness [NEO] Personality Inventory), external validity (with peer ratings), and a five-factor structure (Rammstedt & John, 2007). Supporting this, studies show that the BFI-10 has comparable predictive validity, good convergent and discriminant correlation with the BFI-44 and the NEO-Five Factor Inventory (NEO-FFI; Costa & McCrae, 1992b) across various measures such as academic performance and behavioural observations (Carciofo, Yang, Song, Du, & Zhang, 2016; Thalmayer, Saucier, & Eigenhuis, 2011). Thalmayer et al. (2011) also found that the BFI-10 showed the best predictivity compared to randomly selected 10-item sets from the BFI-44, indicating that

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<sup>4</sup> The ReachOut study, responsible for establishing the baseline questionnaire, omitted one item – item 5, that forms part of the factor 'Extraversion' and is reverse-scored for part of the factor 'Openness to Experience'.

the BFI-10 has selected the most valid items with Cronbach's  $\alpha$  ranging from as low as .43 (agreeableness) up to .72 (extraversion). Internal consistency of the subscales in this study was low, with agreeableness ( $\alpha=.66$ ) displaying the highest internal consistency and all other subscales showing unacceptable measures, Cronbach's  $\alpha < .5$ .

### *Psychological distress*

The short-form 21-item DASS-21 (Lovibond & Lovibond, 1996) examines self-reported transient affective psychological distress differentiated across depression, anxiety and tension/stress. Participants indicate the extent to which they experience each presented statement 'over the past week' on a 4-point Likert-type scale (from *did not apply to me at all*=0, to *applied to me very much, or most of the time*=3). Each of the three dimensions – DASS-Anxiety, DASS-Depression and DASS-Stress – is scored using 7 of the 21 items. As scores increase, depressive, anxious and stress symptomology increases. The assessed constructs correspond to the tripartite theoretical model in clinical and non-clinical studies providing strong reliability with high internal consistency, Cronbach's  $\alpha=.84-.97$  (Clara, Cox, & Enns, 2001; Page, Hooke, & Morrison, 2007), sound construct validity (Lovibond & Lovibond, 1995) and excellent discriminant validity on comparable measures (Antony, Bieling, Cox, Enns, & Swinson, 1998). Importantly, adequate test-retest stability ( $r_s=.71-.81$ ) has been observed (Brown, Chorpita, Korotitsch, & Barlow, 1997). The scale displayed high internal consistency in this study, Cronbach's  $\alpha=.85-.92$ .

## **Measures: Follow-up**

### *Adherence*

An 'adherence' score (in days) was calculated as the continuous dependent variable based on the number of completed EMA entries recorded by the online EMA tool per participant. A valid EMA entry was evaluated as an answer to *any* of the EMA question items

within a period of one day made by a participant. For analysis of variance (ANOVA) statistical examination, a tertile stratification was determined, whereby adherence score splits at 7 days (the mid-point) and 14 days (the recommended protocol length) delimited *low* from *medium*, and *medium* from *high* (above 14 days) adherence groups<sup>5</sup>, respectively.

### *Motivation*

Grounded in Self Determination Theory (Deci & Ryan, 1985), the Intrinsic Motivation Inventory (IMI; Deci & Ryan, 2005) measures aspects of motivation in specific tasks. Selection of up to 7 subscales – Interest-Enjoyment, Perceived Competence, Effort-Importance, Value-Usefulness, Relatedness, Pressure-Tension and Perceived Choice – is possible depending on the investigated activity. Moreover, individual items can be removed if less adapted to the activity under analysis (Deci & Ryan, 2005). The IMI version developed for this study (Table 2) comprised 16 of 45 available items, distributed over 6 of the 7 subscales e.g. “I thought this activity was quite enjoyable, “I did this activity because I wanted to”. Items from the Relatedness subscale, which did not fit the task under investigation were excluded. Participants were asked to indicate how true each statement was in relation to the daily EMA questions on a 7-point Likert scale (from *Not at all*=1 to *Very true*=7). Items were presented in random order with higher scores related to stronger motivation. To achieve this, negatively formulated items were reverse scored (e.g. “I didn’t put much energy into this”).

The psychometric properties and structure of the IMI have been analysed in numerous settings from education through to physical activity. For example, McAuley, Duncan, and Tammen (1989) in a competitive sport setting amongst adolescents focused on Interest-Enjoyment, Perceived Competence, Effort-Importance and Pressure-Tension; internal

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<sup>5</sup> The tertile score splits reflected three approximately evenly distributed subgroups within the EMA protocol group.

consistency was adequate (Cronbach's  $\alpha = .68-.87$ ) for all four specific dimensions. Similarly, in physical education amongst young adults, Goudas and Biddle (1994) found good internal consistency across three dimensions – Interest-Enjoyment (Cronbach's  $\alpha = .82$ ), Perceived Competence ( $\alpha = .83$ ) and Effort-Importance ( $\alpha = .82$ ). Finally, an IMI version modified for Schizophrenia reported good internal consistency (Cronbach's  $\alpha = .92$ ) and test-retest reliability estimates ( $r = .77$ ), and was highly associated with suitable constructs of motivation for health-related behaviours – most importantly with autonomous treatment engagement (Choi, Mogami, & Medalia, 2010). Internal consistency values for this study are displayed in Table 2.

**Table 2.**  
*List of selected Intrinsic Motivation Index items per subscale*

Subscale	Item	Chronbach's $\alpha$
<i>Interest-Enjoyment</i>	This activity did not hold my attention at all.	.77
	I thought this activity was quite enjoyable.	
	I thought this was a boring activity.	
	I would describe this activity as very interesting.	
<i>Perceived Competence</i>	I was pretty skilled at this activity.	.78
	I think I was pretty good at this activity.	
<i>Effort-Importance</i>	I didn't put much energy into this.	.77
	I put a lot of effort into this.	
<i>Pressure-Tension</i>	I felt pressured while doing these.	.70
	I was very relaxed in doing these.	
<i>Perceived Choice</i>	I did this activity because I had to.	.55
	I did this activity because I wanted to.	
	I felt like it was not my own choice to do this task.	
<i>Value-Usefulness</i>	I would be willing to do this again because it has some value to me.	.72
	I believe this activity could be of some value to me.	
	I think this is an important activity.	

### *Automaticity*

The 4-item Automaticity subscale of the Self-Report Habit Index (SRHI; Verplanken & Aarts, 1999; Verplanken & Orbell, 2003) measured automaticity related to the online EMA activity. Participants reported their agreement with the statements “Completing the daily EMA questions was something ... I did automatically / I did without having to consciously remember / I did without thinking / I started doing before I realised I was doing it,” on a 7-point Likert scale (from *strongly disagree*=1 to *strongly agree*=7). Research has previously shown that this subscale is reliable and a valid measure of behavioural automaticity (Gardner, Abraham, Lally, & de Bruijn, 2012). Internal consistency in this study was .86.

### *Cues*

The consistency of time, people, activity, routine, location, and mood as cues to completing the daily online EMA activity were measured using six items consistent with habit theory (Gardner et al., 2012; Lally & Gardner, 2013). Participants were asked how true they found the statements “Each time I completed the daily assessment questions ... it was at the same time of the day / I was around the same people / I was doing the same type of activity / I was in the same place / I was in the same mood,” on a 7-point Likert scale (from *not at all*=1 to *very true*=7). The statements were uniquely adapted from interviews by Pimm et al. (2016), therefore no previous psychometric properties exist.

### *Open-ended questions*

Open-ended questions were presented at the end of the follow-up questionnaire. The first set of these questions asked participants who took part in the EMA about intent, expectations and likes / dislikes. The first of these questions was developed as a query to investigate motivational intent behind participation. This question asked concretely about why participants took part in the EMA. The second question asked what participants expected to gain from the EMA and then measured whether these expectations were met on a 7-point

Likert scale (from *Strongly disagree*=0 to *Strongly agree*=7). A third and fourth question asked about likes (facilitators) and dislikes (potential barriers) of the EMA, respectively.

For participants in the EMA group also classified as not having fully completed the protocol (with number of EMA entries, adherence < 14 days and classified in either the *low* or *medium* tertiles), a question about barriers was presented: “What prevented you from completing the daily assessment questions every day for the two-week period?”. In addition, these participants were asked for suggestions to increase the likelihood of future participation (Appendix 4: Follow-up Questionnaire).

For participants in the non-adherence group (adherence=0), who only received open-ended questions, these were prefaced by the statement: “Thinking about the daily assessment questions described above, please share your thoughts”. Three questions explored barriers, expectations and suggestions, respectively (Appendix 5: Non-adherence Follow-up Questionnaire).

## **Data analysis**

SPSS v24 (IBM) was used throughout and all participant data was codified using user IDs to preserve anonymity. Descriptive statistics were calculated, with chi-squared ( $\chi^2$ ), independent t-tests or z-tests used to compare between independent groups or against the broader ‘population’ sample from the ReachOut study. To evaluate the independent effects of the variables of interest (predictors) – personality, psychological distress, motivation, automaticity and habit-forming cues – with the dependent variable, adherence, two regression analyses were conducted in line with the two quantitative aims of this study (refer Appendix 9: SPSS Regression Command Syntax). This method of analysis was selected for the following reasons – first, the expected multiplicity and correlation among predictors; second, the availability of readily interpretable effect sizes to establish the strength of relationships in

addition to their significance; and third, the capacity to allow for statistical control or partialing of variables that may otherwise influence the inference of results (Cohen, Cohen, West, & Aiken, 2013). Correlations and examination of simple statistics (means) and their comparisons allowed for the preliminary exploration of data as a pretext against which the more complex regression analysis could be conducted and interpreted.

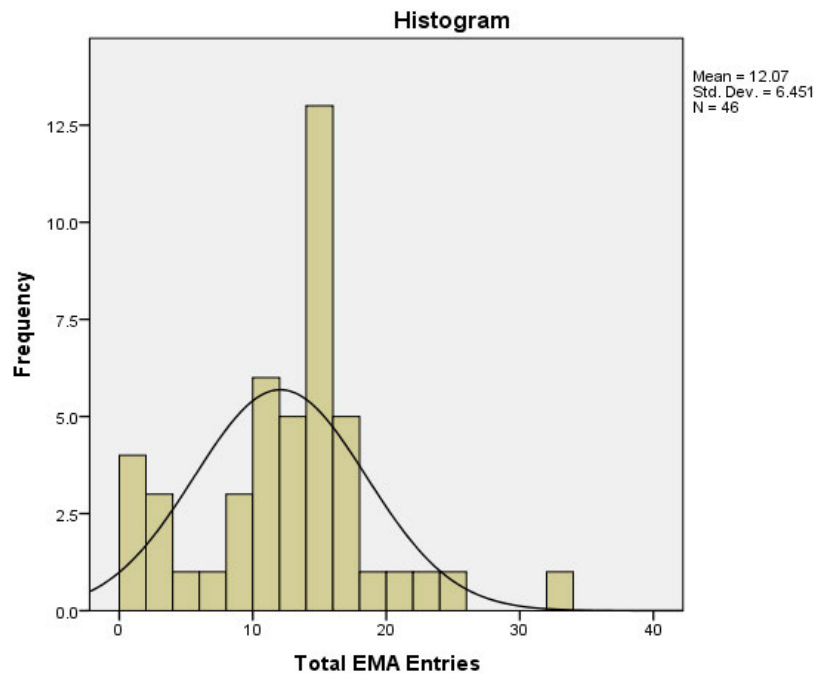
### *Assumption tests*

First, outlier scores for the adherence measure were identified from large Cook's distances,  $D_i > 1.0$  (Cook & Weisberg, 1982), and by examining boxplots for outliers. Three outliers, likely to exert an undue influence on the regression modelling, were omitted, leaving 46 participants<sup>6</sup> in the final data analysis sample. As a result, the Kolmogorov–Smirnov test ( $p > .05$ ) and a visual inspection of the histogram of adherence scores (or number of EMA entries per participant) indicated a normal distribution (Figure 6). For all continuous independent variables, due to the small sample size ( $n < 50$ ), a visual inspection of histograms and Q-Q plots confirmed normal distributions. Similarly, visual inspection of scatterplots confirmed that all relationships were both linear and homoscedastic. To identify any causes of multicollinearity, the Variance Inflation Factors (VIFs), were examined for all selected predictors in the final regression model to ensure they remained acceptable at  $< 10$  (Field, 2013). Finally, independence of errors (autocorrelation) was inspected with the Durban-Watson index,  $d$ , approaching 2.0 (Field, 2013).

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<sup>6</sup> One of the three outlier participants failed to answer the Value-Usefulness IMI subscale. A further two participants neglected to complete questions in relation to automaticity and habit-forming cues. Data from these participants was imputed using a mean value where analyses involved these variables.





**Figure 6.** Histogram of EMA entries per participant

An indication of adherence rates with three outliers removed to meet normality criteria ( $n=46$ ).

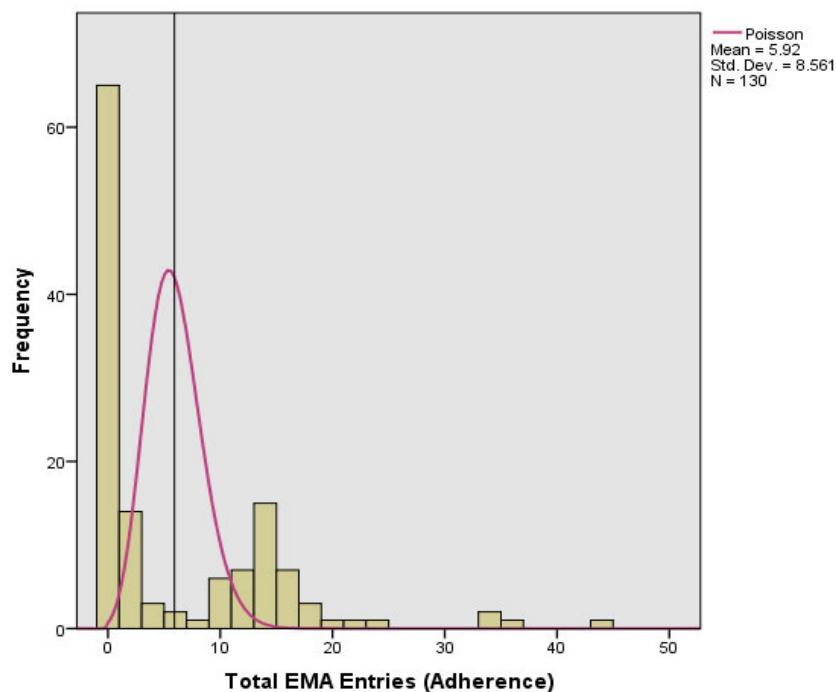
#### *Data-driven variable selection*

Pearson correlations tested the bivariate relations between each of the independent variables with adherence. Only correlates with coefficients  $p < .25$  were considered for inclusion in the regression models (Hosmer Jr, Lemeshow, & Sturdivant, 2013). Further to this, an ANOVA analysis was undertaken to compare mean scores of all possible continuous predictor variables across the three adherence strata (*low*, *medium*, and *high*).

#### *Aim 1: Non-linear regression analysis*

The first regression analysis included the total baseline sample of all participants ( $N=130$ , no outliers omitted) with adherence as the dependent variable. The adherence scores (treated as ‘counts’ equivalent to the number of days of EMA entries) displayed an over-dispersed distribution ( $M_{adherence}=5.92$ ,  $SD=8.56$ ,  $Variance=73.3$ ), where the mean was substantially less than the variance. This observed non-uniform distribution was supported by both positive kurtosis ( $\kappa=3.497$ ,  $SE=0.42$ ) and positive skew ( $\gamma=1.73$ ,  $SE=0.21$ ), and

necessitated a generalised linear model (GLM), specifically a negative binomial with a log() link function. Due to the high clustering of adherence scores of zero attributed to the non-adherence group (Figure 7), a zero-inflated regression analysis was conducted<sup>7</sup> (Beaujean & Morgan, 2016). Data-driven and theoretical predictors were included in the model – gender (as a dummy-coded categorical variable); age; personality factors from the BFI-10: agreeableness, neuroticism, and conscientious; and psychological distress scores for depression, anxiety and stress from the DASS21.



**Figure 7.** Histogram of EMA entries per participant (with non-adherence group)

An indication of adherence rates with non-adherence cluster at 0 included for negative binomial distribution ( $N=130$ ).

Using Akaike's Information Criterion (AIC) as a comparative fit index confirms that this model,  $AIC_{ZINB}=633$ , fit the over-dispersed data (over-dispersion parameter,  $\theta=2.09$ ) better than an equivalent zero-inflated Poisson (ZIP) model,  $AIC_{ZIP}=779$ , where smaller AIC

<sup>7</sup> There were no built-in zero-inflated model options in SPSS, however an extension (STATS ZEROINFL) was used in conjunction with the R plugin available for SPSS.

values signify better fit. A zero-inflated model provides two sets of coefficients – count regression and logistic regression. The coefficients for the count regression are exponentiated for interpretation and presented as an Incident Rate Ratio (IRR). The coefficients for the logistic regression are on the logit scale, so exponentiating them transforms the values to odds ratios (OR; Beaujean & Morgan, 2016).

### *Aim 2: Linear regression analysis*

The final hierarchical multiple linear regression analysis ( $\alpha=.05$ ) adopted block entry to determine predictors of adherence. This sample consisted *only* of the participants (outliers removed) who took part in the EMA and responded to the follow-up questionnaire. In this sample, the ‘adherence’ dependent variable demonstrated a normal distribution (Figure 6),  $M_{adherence}=12.07$ ,  $SD=6.45$ . Assumptions of normality, linearity, and homoscedasticity were initially assessed, and found to be supported for all variables (Appendix 8: Assumption Tests). Age, gender, the identified Big Five personality factors (conscientiousness, agreeableness and neuroticism), and Psychological distress subscales of interest (stress and anxiety) were entered on the first step to determine the initial model ‘goodness of fit’ from baseline predictors on the EMA adherence group (step 1). To include the additional follow-up measures from this study, a second step consisted of adding the theoretically determined motivational orientation indices followed by a third step with the motivational orientation indices identified through data-driven analysis. A final step added the automaticity subscale determinant of habit-formation. Interaction terms incorporating automaticity with motivation were not interpreted in the final analysis due to the non-significant outcomes of automaticity as a predictor of adherence. Missing data were replaced by the imputed mean of each variable. The statistic values generated were unstandardised coefficients ( $B$ ),  $F$ -statistics,  $R^2$ , delta ( $\Delta$ )  $R^2$  and levels of significance of predictors and of the  $F$ -change at  $p<.05$ .

*Aim 3: Qualitative analysis*

To address the third aim of this study exploring participants experiences, a thematic analysis (Braun & Clarke, 2006) of open-ended free-text questions was conducted. Themes were identified from both the non-adherence and EMA group responses. An independent observer<sup>8</sup> validated the selection of themes.

*Power analysis*

A post hoc statistical power analysis, with sample size 46 ( $\alpha < .05$ ), was performed using GPower v3.1 (Faul, Erdfelder, Buchner, & Lang, 2009). The power was less than .16 for detecting small effects<sup>9</sup>, whereas the power reached .73 for moderate effects and exceeded .97 for large effects (Appendix 6: Power Analysis). Thus, there was only adequate power (i.e.  $> .80$ ) at large effect levels, and less than adequate statistical power at small effect levels.

An a priori power analysis for a linear regression with up to 8 predictors revealed that 652 participants were required for suitable power to detect small effect sizes. Given the exploratory nature of this study with access to an available sample of only 65 participants, the results should be interpreted as indicative of effect sizes (rather than solely for significance) and to inform future research.

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<sup>8</sup> Dr. Camille Short

<sup>9</sup> Recommended effect sizes – small ( $f^2 = .02$ ), medium ( $f^2 = .15$ ), and large ( $f^2 = .35$ ) (Cohen, 1992).

## Results

### Descriptive statistics

Overall adherence for the 14-day intervention was moderate in the group that chose to participate in the EMA ( $n=65$ ,  $M_{adherence}=11.85$  days,  $SD=8.75$ ), with 30 of the 65 participants (46.2%) completing the required 14-day protocol. Forty-nine of the 65 participants (75.4% [49/65]), who commenced the EMA, responded to this follow-up study (refer Table 1 Personal Characteristics). Despite the narrow age range (16.17–27.25 years), the EMA participants tended to be significantly younger than those in the ‘non-adherence group’ ( $t(128)=2.08$ ,  $p=.04$ ). Although, no differences were noted across the Big Five Index (BFI-10) measures of personality factors. Notably, mean scores on all three subscales of the DASS21 psychological distress measures were close to or within *moderate to severe* normative ranges<sup>10</sup>, placing these individuals ‘at-risk’ of clinical disorders. Participants in the ‘EMA protocol group’ displayed significantly lower anxiety and stress scores than the ‘non-adherence group’,  $t(128)=2.78$ ,  $p=.006$  and  $t(128)=2.99$ ,  $p=.003$  respectively (Table 3). Similar significant differences of lower anxiety and stress scores were observed in the follow-up responders when compared to the total ReachOut study sample,  $z=2.61$ ,  $p=.009$  and  $z=2.44$ ,  $p=.015$  respectively (Table 4).

**Table 3.**  
Descriptive statistics of baseline study measures with group comparisons

Characteristic		Total sample	Group		$\chi^2$ or independent t-test
		ReachOut study (N=130)	Non-adherence (n=65)	EMA protocol (n=65)	
<i>Gender</i>	Male % (n)	7.0% (9)	7.7% (5)	6.2% (4)	$\chi^2(1)=0.11$
	Female % (n)	90.8% (118)	89.2% (58)	92.3% (60)	$\chi^2(1)=0.37$
	Other % (n)	2.2% (3)	3.1% (2)	1.5% (1)	$\chi^2(1)=0.37$

<sup>10</sup> Australian normative data (Crawford, Cayley, Lovibond, Wilson, & Hartley, 2011): Moderate scores (percentile range, 84%–97.7%) for the DASS21: Depression, 7–10; Anxiety, 6–7; Stress, 10–12. Severe scores (percentile range, 97.7%–99.87%) for the DASS21: Depression, 11–13; Anxiety, 8–9; Stress, 13–16.

Characteristic		Total sample	Group		$\chi^2$ or independent t-test
		ReachOut study (N=130)	Non-adherence (n=65)	EMA protocol (n=65)	
<i>Age</i> (years)	<i>M (SD)</i>	21.01 (2.48)	21.46 (2.48)	20.57 (2.41)	$t(128)=2.08^*$
	range	16.17–27.25	16.17–26.5	16.5–27.25	-
<i>Adherence</i>	<i>M (SD)</i>	-	-	11.85 (8.75)	-
	% (n)	-	-	46.2% (30)	-
<i>Personality</i> <i>BFI-10</i>	Openness	7.7 (2.28)	7.82 (2.22)	7.6 (2.32)	$t(128)=0.55$
	Conscientious.	6.48 (1.86)	6.46 (1.79)	6.51 (1.94)	$t(128)=0.15$
	Extraversion	4.32 (2.20)	4.36 (2.18)	4.28 (2.26)	$t(128)=0.21$
	Agreeableness	6.61 (1.90)	6.75 (2.07)	6.46 (1.71)	$t(128)=0.87$
	Neuroticism	8.16 (1.56)	8.2 (1.70)	8.12 (1.43)	$t(128)=0.29$
<i>Psychol.</i> <i>State</i>	Depression	10.19 (5.84)	11.09 (5.37)	9.29 (6.19)	$t(128)=1.77$
	Anxiety	7.38 (4.90)	8.55 (4.83)	6.22 (4.72)	$t(128)=2.78^{**}$
<i>DASS21</i>	Stress	10.89 (5.08)	12.18 (4.51)	9.60 (5.31)	$t(128)=2.99^{**}$

Note: Variables are shown as either Mean (SD) or % (n) where appropriate

\*  $p < .05$  \*\*  $p < .01$

**Table 4.**  
Descriptive statistics of study measures for follow-up participants

Characteristic		Total sample	EMA follow-up (n=49)	one sample z-test
		ReachOut study (N=130)		
<i>Gender</i>	Male % (n)	7.0% (9)	4.1% (2)	$z=0.8^\dagger$
	Female % (n)	90.8% (118)	93.9% (46)	$z=0.8^\dagger$
	Other % (n)	2.2% (3)	2.0% (1)	$z=0.1^\dagger$
<i>Age</i> (years)	<i>M (SD)</i>	21.01 (2.48)	20.76 (2.45)	$z=0.71$
	range	16.17–27.25	16.5–27.25	-
<i>Adherence</i>	<i>M (SD)</i>	-	13.36 (8.86)	-
	% (n)	-	53.1% (26)	-
<i>Personality</i> <i>BFI-10</i>	Openness	7.7 (2.28)	7.67 (2.32)	$z=0.09$
	Conscientious.	6.48 (1.86)	6.57 (1.89)	$z=0.34$
	Extraversion	4.32 (2.20)	4.12 (2.18)	$z=0.64$
	Agreeableness	6.61 (1.90)	6.51 (1.74)	$z=0.37$
	Neuroticism	8.16 (1.56)	8.00 (1.41)	$z=0.72$
<i>Psychol.</i> <i>State</i>	Depression	10.19 (5.84)	8.67 (6.02)	$z=1.82$
	Anxiety	7.38 (4.90)	5.55 (4.69)	$z=2.61^*$
<i>DASS21</i>	Stress	10.89 (5.08)	9.12 (5.42)	$z=2.44^*$

Characteristic		Total sample ReachOut study (N=130)	EMA follow-up (n=49)	one sample z-test
<i>Motivation</i>	Effort-Importance	-	4.84 (1.48)	-
<i>IMI</i>	Value-Usefulness	-	5.39 (1.05)	-
	Perceived-Choice	-	6.14 (0.92)	-
	Perceived-Comp.	-	4.50 (1.05)	-
	Pressure-Tension	-	2.39 (1.10)	-
	Interest-Enjoy.	-	4.88 (0.97)	-
<i>Habit Index</i>	Automaticity	-	14.04 (4.94)	-
<i>Cues</i>	Time	-	4.30 (1.71)	-
	People	-	2.98 (1.98)	-
	Activity	-	3.91 (1.74)	-
	Routine	-	3.83 (1.74)	-
	Place	-	4.23 (2.04)	-
	Mood	-	2.79 (1.38)	-

Note: Variables are shown as either Mean (SD) or % (n) where appropriate

† proportional difference test

\*  $p < .05$  \*\*  $p < .01$

## Identification of predictors

### Variable selection

Before multivariate regression calculations, bivariate correlations were conducted to examine the relationships between all continuous predictor variables – both baseline and additional measures – and EMA adherence as a continuous dependent variable in the ‘EMA protocol group’ (Table 5 and Table 6). Of note, the Intrinsic Motivation Index (IMI) scores for the Value-Usefulness subscale significantly correlated with adherence ( $r=.38, p=.008$ ). Also, individual higher scores on the BFI-10 agreeableness personality factor subscale were positively associated with adherence ( $r=.26, p=.04$ ).

**Table 5.**  
Pearson correlation matrix for all baseline variables

	Age	Personality (BFI-10)					Psychological distress (DASS21)		
		Open.	Consc.	Extrav.	Agree.	Neurot.	Depr.	Anx.	Stress
<i>Adherence</i>	.15 <sup>†</sup>	-.07	.23 <sup>†</sup>	-.09	.26*	-.23 <sup>†</sup>	-.05	-.07	.06
<i>Age</i>		.08	.14	-.08	-.02	-.10	-.05	-.10	-.15
<i>BFI-10</i>									
Open.			.14	-.05	.02	.10	-.07	.06	.13
Consc.				.04	.26*	.06	-.21	-.19	-.03
Extrav.					.31*	-.03	-.12	-.06	-.11
Agree.						-.20	-.21	-.24	-.18
Neurot.							.29*	.52**	.49**
<i>DASS21</i>									
Depr.								.61**	.60**
Anxiety									.81**

\*  $p < .05$  \*\*  $p < .01$

<sup>†</sup>  $p < .25$

**Table 6.**  
Pearson correlation matrix for additional follow-up measures

	Motivation (IMI)					Habit Index (SRHI)	
	E-I	V-U	P-Ch.	P-Co.	P-T	I-E	Automaticity
<i>Adherence</i>	.21 <sup>†</sup>	.38*	.11	.18 <sup>†</sup>	-.19 <sup>†</sup>	.09	.10
<i>IMI</i>							
Effort-Imp.		.33*	-.03	.15	-.21	.27	.24
Value-Use.			.41**	.29*	-.44**	.65**	.38**
Per.-Choice.				.11	-.37**	.31*	.09
Per.-Comp.					-.28	.52**	.36*
Press-Tens.						-.36*	-.27
Interest-Enj.							.36*

\*  $p < .05$  \*\*  $p < .01$

<sup>†</sup>  $p < .25$

No other significant correlations with adherence were observed; instead the correlations were used to inform data-driven regression analysis. Five additional predictors with coefficients  $p < .25$  were identified: age ( $r = .15$ ,  $p = .24$ ); the BFI-10 neuroticism ( $r = -.23$ ,



$p=.07$ ) and conscientiousness ( $r=.23, p=.07$ ) personality factors; and, the IMI Effort-Importance ( $r=.21, p=.15$ ), Perceived Competence ( $r=.18, p=.22$ ), and Pressure-Tension ( $r=.19, p=.18$ ) subscales.

### *Analysis of variance*

When adherence was categorised into *low*, *medium* and *high* tertiles, an analysis of variance (ANOVA) showed that the effect on adherence of the agreeableness BFI-10 personality factor, and, the Value-Usefulness and Effort-Importance motivational orientations, were significant –  $F(2,59)=4.43, p=.049$ ;  $F(2,43)= 4.90, p=.012$ ; and  $F(2,43)= 3.24, p=.049$  respectively. These results were consistent with the correlation analysis and provide further data-driven support for the inclusion of BFI-10 agreeableness, IMI Value-Usefulness and Effort-Importance in subsequent regression analyses. Upon examination, all IMI variables displayed visible non-linear associations across the three adherence categories, with notably lower scores on these measures observed in the *high* adherence tertile. All other mean distributions were in the expected directions (refer Appendix 7: Comparison of Means across Tertiles).

### **Aim 1: Who did and did not adhere to the EMA**

#### *Regression: Zero-inflated negative binomial*

The total ReachOut sample ( $N=130$ ) included all participants who did not attempt the EMA and therefore recorded an adherence score of 0 ( $n=65$ ). Therefore, to investigate the first research aim – predictors related to *who* did and did not adhere to the EMA – a zero-inflated negative binomial (ZINB) was calculated to account for excess zeros (Beaujean & Morgan, 2016). This model simultaneously examines non-occurrence of the outcome (i.e. non-adherence or the presence of zero adherence score values) using a logistic regression, and how frequently adherence (count) scores occur.

An examination of coefficients revealed that adherence increased amongst participants who were more stressed (IRR=1.08, 95% CI[1.00, 1.17]). Conversely, adherence decreased amongst participants who scored higher on the neuroticism BFI-10 personality factor (IRR=0.85, 95% CI[0.72, 0.99]). The logistic regression coefficients, expressed as an odds ratio (OR), indicated that participants older in age were significantly more likely to be in the non-adherence group (OR=1.20, 95% CI[1.02, 1.42]). Any further interpretation about the strength and significance of associations for predictor variables should be tempered, since the effects were small and 95% CI values contained 1.0. Table 7 presents the ZINB model parameters.

**Table 7.** Zero-Inflated Negative Binomial model parameters (N=130)

		Count					Logistic (zero-inflation)				
		<i>B</i>	<i>SE</i>	exp( <i>B</i> ) (IRR)	95% CI		<i>B</i>	<i>SE</i>	exp( <i>B</i> ) (OR)	95% CI	
					<i>L</i>	<i>U</i>				<i>L</i>	<i>U</i>
<i>Age</i>		0.07	0.05	1.07	0.98	1.17	0.19*	0.08	1.20	1.02	1.42
<i>Gender</i>	Male <sup>a</sup>	-	-	-	-	-	-	-	1.00	-	-
	Female	0.06	0.43	1.06	0.46	2.44	-0.39	0.75	0.67	0.15	2.94
	Other	0.39	0.92	1.48	0.24	8.94	0.22	1.54	1.24	0.06	25.44
<i>Personality</i>	Consc.	0.06	0.06	1.06	0.95	1.18	-0.04	0.12	0.96	0.76	1.22
<i>BFI-10</i>	Agree.	0.08	0.06	1.09	0.96	1.23	0.17	0.12	1.18	0.94	1.49
	Neurot.	-0.17*	0.08	0.85	0.72	0.99	-0.21	0.15	0.81	0.61	1.09
<i>Psychol.</i>	Depr.	-0.02	0.02	0.98	0.93	1.02	-0.01	0.04	0.99	0.90	1.07
<i>State</i>	Anxiety	-0.02	0.04	0.98	0.90	1.07	0.05	0.07	1.05	0.93	1.20
<i>DASS21</i>	Stress	0.08*	0.04	1.08	1.00	1.17	0.14 <sup>b</sup>	0.07	1.15	1.00	1.32

*Note.* *B*: Unstandardised coefficient; *SE*: Standard error; exp(*B*): Exponentiated regression coefficient, equivalent to Odds Ratio (OR) for logistic regression and Incident Rate Ratio (IRR) for count regression. Log Likelihood=-296 (*df*=17); AIC<sub>ZINB</sub>=633.

<sup>a</sup> Reference category for Gender dummy-coded variable

<sup>b</sup>  $p < .06$

\*  $p < .05$

**Aim 2: Why individuals adhered to the EMA***Regression: Linear hierarchical*

To research the second study aim – predictors related to *why* participants adhered to the EMA – a linear hierarchical multiple regression analysis was used to examine whether self-reported ratings on motivational factors, and automaticity would predict final adherence rates for those who did engage in the EMA over the 14-day period. Table 8 presents the comparisons for each model.

**Table 8.**  
Results of hierarchical regression models predicting adherence ( $n=46$ )

Step	Predictor variable added	$R^2$	adjusted $R^2$	$\Delta R^2$	$F$	$p_F$	$\Delta F$	$p_{\Delta F}$
1 (baseline)	Gender Age Neurot. Consc. Agree. Anxiety Stress	.29	.16	-	2.27*	.050	-	-
2 <sup>†</sup>	Value-Useful. Interest-Enj.	.42	.28	.13	2.93*	.010	4.02*	.027
3	Perc. Comp. Effort-Imp Press-Tension	.43	.22	.01	2.08*	.047	0.16	.925
4	Automaticity	.44	.22	.01	1.96	.061	0.66	.423

Note.  $R^2$ : coefficient of variance;  $\Delta F$ : Change in F-statistic from previous model.

<sup>†</sup> Most efficient model (largest adjusted  $R^2$ ), since additional predictors in model steps 3 and 4 did not significantly improve the overall model. Durbin-Watson index,  $d=1.13$

\*  $p < .05$

The baseline model (step 1) was significant,  $F(7,38)=2.27$ ,  $p=.05$ , although accounted for only 29% of the variance in adherence rates, with an adjusted  $R^2=.16$ . The most efficient model (step 2) significantly predicted adherence to the EMA,  $F(9,36)=2.93$ ,  $p=.01$ ,

accounting for 42.3% of the variance in adherence rates, with an adjusted  $R^2=.28$ . This model also demonstrated a significant improvement ( $\Delta F=4.02$ ,  $p_{\Delta F}=.027$ ) over the baseline model,  $\Delta R^2=.13$ . However, neither the addition of data-driven motivational orientation variables (step 3), nor the inclusion of automaticity (step 4), improved the overall model; explaining only an additional 1% of the variance in adherence with each incremental step,  $\Delta R^2=.01$ .

Examination of all predictor variables, in the most efficient model (step 2), revealed that the Value-Usefulness subscale of the IMI and the agreeableness BFI-10 personality factor were significant predictors of adherence (Table 9). Stated otherwise, every unit increase in Value-Usefulness scores is associated with a more than 3-day increase in adherence, and every unit increase in agreeableness scores is associated with a 1.28-day increase in adherence. Surprisingly, the Interest-Enjoyment motivational orientations showed a negative association with adherence despite non-significance.

**Table 9.**  
Regression model from step 2 - coefficients predicting adherence (n=46)

Predictor Variable	B (SE)	95% Confidence Interval		p
		Lower	Upper	
Gender	-5.02 (3.53)	-12.17	2.13	.163
Age	0.23 (0.36)	-0.61	0.95	.522
Neurot.	-0.99 (0.71)	-2.50	0.46	.171
Consc.	0.42 (0.50)	-0.70	1.51	.407
Agree.	1.28 (0.56) *	-0.13	2.38	.029 *
Anxiety	0.37 (0.34)	-0.45	1.04	.282
Stress	0.00 (0.29)	-0.58	0.66	.999
Value-Useful.	3.01 (1.1) *	0.87	5.47	.009 *
Interest-Enj.	-1.50 (1.18)	-3.98	0.93	.211

Note. B: Unstandardised coefficient; SE: Standard error.

\*  $p < .05$

*Interaction effects and exploration of cues*

Interaction effects between the two theory-based motivation index subscales – Value-Usefulness and Interest-Enjoyment – and the automaticity scale on the self-report habit index (SRHI) were added to the model, analysed and found non-significant ( $B=-0.24$ ,  $p=.28$  and  $B=0.21$ ,  $p=.35$  respectively). These findings are difficult to further interpret in this study because the effect of automaticity on adherence of its own accord was non-significant ( $B=-0.18$ ,  $SE=0.22$ ,  $p=.42$ ) – therefore any interaction effects incorporating automaticity are unlikely to be valid. Similarly, the presence of associated contextual cues was not interpretable as a predictor of adherence. As a result, no further analysis was conducted on the contextual cue associations, nor their interaction effects on adherence. However, it was noted that cues for ‘time’ and ‘place’ received higher ratings on the 7-point Likert scale,  $M_{cue\_time}=4.30$  ( $SD=1.71$ ) and  $M_{cue\_place}=4.23$  ( $SD=2.04$ ), than those for ‘people’ and ‘mood’,  $M_{cue\_people}=2.98$  ( $SD=1.98$ ) and  $M_{cue\_mood}=2.79$  ( $SD=1.38$ ).

**Aim 3: Barriers, facilitators and experiences**

Thematic analysis of open-ended questions revealed several themes; conceptualised within 5 distinct overarching domains: (1) Motivational Intent, (2) Expectations (and whether they were met), (3) Facilitators, (4) Barriers, and (5) Suggestions. In addition, overall experiences were optionally recorded by a small number of participants (8.7%) in response to a question seeking additional input: “*Please feel free to write additional comments about any aspects of your experience*”. Themes are summarised in Table 10 with illustrative participant quotes shown.

*Motivational intent*

In response to the question: “*Why did you take part in the daily assessment questions?*”, participants mostly identified either ‘contribution to research’ (26.5%) or

‘gaining insights into their mood, wellbeing or general trends’ (32.7%) as the most salient reasons. Some participants referred to ‘personal health outcomes’ (14.3%), or believed that the EMA would be of ‘interest’ (18.4%). Other participants indicated that the study ‘incentive’ was their motivation (8.2%). Of note, ‘personal health outcomes’ and ‘incentives’ were mentioned more prominently by participants in the *low* adherence group, compared to ‘insights’ and ‘interest’ in the *medium* and *high* adherence groups.

### *Expectations*

Regarding expectations, more than half of the participants (62%) again referred to self-awareness, self-reflection and ‘insights’ into mood patterns when answering the question “*What did you expect to gain from the daily assessment questions?*”. Other themes raised by many participants included the expectation of an external ‘reward’ upon completion of the study (4.4%) and an indication of ‘no expectations’ (22%).

**Table 10.***Thematic analysis with responder illustrative quotes*

Question	Theme	Illustrative Quote
<i>Motivational Intent</i>		
	Contribute to Research	“To participate in research that may assist in developing future interventions or changing people's attitudes and behaviours toward exercise and its ability to alter mood” “I wanted to help out in the research”
	Insight and awareness	“I thought it might give me more awareness and insight into my moods.” “I personally wanted to see how my mood and energy would change over time and just as a way to monitor myself”
	Interest	“I thought it would be an interesting observation into my moods and daily life.”
	Personal Health Outcomes	“To try see if I could improve my wellbeing” “I felt that it would assist in improving my mood”
	Incentive	“For the gift card” “...there was a reward”
<i>Expectations</i>		
	Insight and awareness	“I expected to gain an insight into particular patterns that may occur during my week” “A better understanding of how my mood affects energy levels, exercise etc...”
	Incentive	“A voucher”
	Unsure	“I wasn't entirely sure” “Nothing in particular”

Question	Theme	Illustrative Quote
<i>Facilitators</i>		
	Simplicity	<p>“I liked the ease of use”</p> <p>“Straight-forward”</p> <p>“They were easy to do and quick to complete”</p>
	Self-awareness	<p>“It gave me time t stop and check in with myself”</p> <p>“I liked being able to stop and think about how i felt during the day and i guess briefly reflect on my mood and how my actions contributed to it”</p>
	Technology	<p>“The sliding scales and being able to compare it”</p> <p>“The scale was really impressive for a lot of the mood and energy levels”</p>
	Feedback	<p>“I liked that they created a graph for me to see how they changed day to day and over a longer period.”</p> <p>“...that it showed you how your answers compared to other days”</p>
<i>Barriers</i>		
	Forgetfulness	<p>“I had to remember to do them.”</p> <p>“Sometimes I couldn't remember what I had eaten or how long I had exercised for”</p>
	Repetition	<p>“Boring and repetitive”</p> <p>“A little repetitive”</p>
	Lack of depth	<p>“I would like more lifestyle factor questions like caffeine intake, work out or not etc”</p> <p>“It didn't take into account other circumstances that could effect mood”</p>
	Technology	<p>“The website was a bit odd to use”</p> <p>“I found it was a bit difficult to use on a mobile, it could do with some compatibility improvements”</p>



Question	Theme	Illustrative Quote
<i>Suggestions</i>		
	Smartphone application	<p>“Having an app that gives notifications”</p> <p>“Making this as an app that makes it easy to complete daily without having to log into a webpage may also be useful.”</p> <p>“SMS reminders, or having them within an app that would also give daily reminders”</p> <p>“Utilise an app based assessment process”</p>
	Improve existing reminders	<p>“Maybe text reminders. All I got was emails and some days I won't check my emails.”</p> <p>“Perhaps a different time of day to be reminded when things were not so busy”</p>
	Extend EMA questions	<p>“If there were more emotions to pick from”</p> <p>“Make it more fun and less questions as I ran out of time”</p>
<i>Experiences</i>		
		<p>“I think being part of this study has made me seek out other ways to improve my health and become more mindful e.g. regularly doing yoga, starting a mindfulness meditation practice, being more mindful of my health in other ways. I am feeling really great at the moment.”</p> <p>“It's a wonderful idea and I wished I had participated more fully in it!”</p>

## Expectations met

Participants from the 'EMA protocol group', indicated on a 7-point Likert scale that their expectations were mostly met,  $M_{Expectations}=4.74$ ,  $SD=1.34$ . An ANOVA revealed significant differences,  $F(2,43)=5.96$ ,  $p=.005$ , in the reported 'expectations met' scores across the three tertiles – *high*, *medium*, and *low* (Figure 8). More specifically, a Tukey HSD post-hoc analysis indicated significant differences between the *low* ( $M_{Expectations}=3.29$ ,  $SD=1.98$ ) and *high* ( $M_{Expectations}=4.96$ ,  $SD=1.08$ ), and between the *low* and *medium* ( $M_{Expectations}=5.08$ ,  $SD=0.95$ ) adherence tertiles (Table 11).

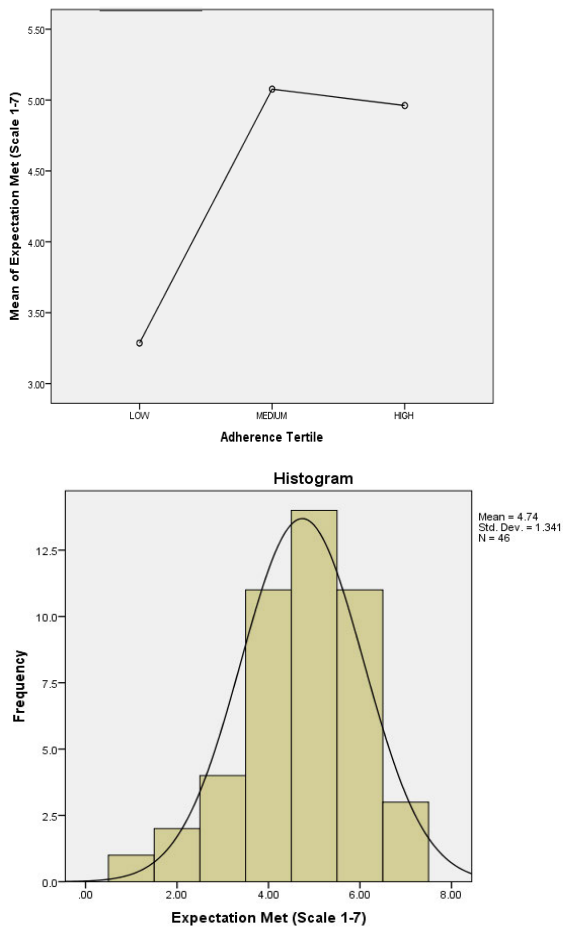


Figure 8. Comparison of 'expectations met' across tertiles and score distribution

**Table 11.**  
Tukey HSD comparison for 'expectations met'

Adherence Tertile (I)	Adherence Tertile (J)	$M_{Expectations}$ Difference (I-J)	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
High	Medium	-0.12	0.41	-1.12	0.89
	Low	1.68*	0.52	0.42	2.93
Medium	High	-0.12	0.41	-0.89	1.12
	Low	1.79*	0.57	0.41	3.17

\*  $p < 0.05$

### Facilitators

Simplicity (36%) and self-awareness (27%) were the most common themes raised by participants to demonstrate facilitators in response to the question: "What did you like about the daily assessment questions?". A few respondents reported that they liked the 'feedback' and aspects of the 'technology'.

### Barriers

The study sought to identify potential barriers to EMA adherence through the question: "What didn't you like about the daily assessment questions?". Participants in the low and medium adherence tertiles were also asked the question: "What prevented you from completing the daily assessment questions?". Since the above questions did not apply to participants who did not take part in the EMA, the non-adherence sample were specifically asked the question: "Why didn't you take part in the daily assessment questions?".

Participants mostly identified the repetitiveness (18%) of the questions and their own forgetfulness (18%) as barriers to adherence or participation, with a few participants indicating a lack of depth in the questions (8.9%) and aspects of the technology (15.6%) as issues.

### *Suggestions*

Suggestions were sought from EMA participants in the *low* and *medium* adherence tertiles and in the non-adherence group, with the question: “*What would you suggest, to increase the likelihood that you would complete / take part in the daily assessment questions?*”. Most participants suggested that the EMA should be a ‘smartphone application’ incorporating better reminders (66%), with a few participants making suggestions for improvements to the existing ‘reminders’ (22%) and the ‘EMA questions’ themselves (8%).

## Discussion

This mixed-methods study examined practically relevant individual differences, including self-determination and habit-formation, that predict adherence to a recommended 14-day e-health Ecological Momentary Assessment (EMA) protocol in distressed young people. To the author's knowledge, this study is the first to observe associations between such factors and adherence to EMA, specifically the processes derived from Habit Theory (Lally & Gardner, 2013) and Self-Determination Theory (SDT; Deci & Ryan, 1985) that are fundamental to these relationships. As such, this study extends previous research, which, for EMA, has focussed primarily on exploring adherence in connection with specific study design characteristics only (e.g. Wen et al., 2017).

### Summary of results and implications

The modest EMA adherence rate (46.2%) observed in the present study is consistent with population-based EMA studies conducted in naturalistic settings (van der Krieke et al., 2016); confirming the wide-spread problem of adherence to EMA. Whilst recent EMA studies explicitly addressing issues of adherence have noted progress in containing the burden of EMA (Burke et al., 2017), they were not conducted with samples 'at-risk' of mental-health disorders. Since the sample of young people in this study were purposefully recruited from the ReachOut mental-health support website, they were characteristic of the demographic of visitors to that site, mostly educated females aged 16-27 (Metcalf & Blake, 2014). Importantly though, they exhibited high psychological distress scores on measures of depression, anxiety and stress (DAS21); indicative of *moderate* to *severe* mental-health problems compared to normative Australian data (Crawford et al., 2011).

*Aim 1: Individual differences – personality and demographics*

The first aim of the present study was to identify predictors related to *who* did and did not adhere to the EMA protocol. Specifically, the first hypothesis was concerned with whether individual differences of personality were associated with adherence. There was strong empirical evidence for the hypothesis (H1b) that high scores on the short-form Big Five Index (BFI-10) personality factor of *agreeableness* positively associate with adherence. This is in keeping with findings from other studies, which note the link between agreeableness and cooperative or compliant behaviour (Hansen et al., 2013). Similarly, there is sufficient evidence for the hypothesis (H1c) that high scores on the BFI-10 *neuroticism* subscale are negatively associated with adherence. Again this finding supports previous research that individuals displaying neuroticism are prone to impulsivity and disposed to amotivation and disinterest (Axelsson et al., 2011; Hansen et al., 2013). Such traits may possibly inhibit the scarce resources of self-control and attention needed to repeatedly complete (i.e. adhere to) self-report EMA items (Muraven & Baumeister, 2000).

In contrast to past research (Axelsson et al., 2011), there was no support, however, for the hypothesis (H1a) that *conscientiousness* is positively associated with adherence. Conscientiousness is a factor of personality that represents several distinct but correlated personality traits or facets, which include a preference for order, the motivation to achieve goals, and self-discipline, among others (Costa & McCrae, 1992b; Paunonen, 2003). One possible explanation for this discrepancy with previous studies might be due to limitations with the short-form BFI-10 in differentiating such underlying facets. This is particularly relevant given the unacceptably low internal consistency of the BFI-10 conscientiousness subscale noted in this study (Chronbach's  $\alpha < 0.5$ ). This raises questions about how reliably the BFI-10 evaluates high-level personality factor constructs. Future EMA studies may seek a deeper understanding of the relationship between adherence and underlying personality traits

using extended measures, such as the more comprehensive NEO Personality Inventory (Costa & McCrae, 1992b).

Also, consistent with recent reviews (e.g. Killikelly et al., 2017), there was no evidence in this study that *gender* difference predicts adherence. Clearly though, with over 90% of the present sample being female, the underrepresentation of male participants may have effected this statistical outcome – a common challenge for psychological research (Ellis et al., 2014; Patel, Doku, & Tennakoon, 2003). Moreover, the previously reported power analysis for this study suggests that the modest sample size ( $n=46$ ) would detect medium effects only. Therefore, to overcome power issues in future studies, data should be collected from larger samples to discern smaller effect sizes. Additionally, more dedicated efforts should be made to recruit male participants – possibly using targeted social media campaigns aimed at engaging young men (Ellis et al., 2014).

Nevertheless, two of the more striking observations within the first aim of this study are: (1) the influence of *age*, with younger participants more likely to commence the EMA; and, (2) the revelation that participants with higher *stress* exhibit higher adherence. The second finding is particularly interesting given that overall stress in the adherence group was significantly lower than in the non-adherence group. This suggests that once individuals engage with the EMA, those with higher stress levels are more likely to persist.

#### *Aim 2: Motivation and habit-formation*

The challenge with EMA, highlighted in the existing literature and in this study, appears to be two-fold, both, to increase participation in EMA, and, to ensure continued adherence (e.g. Trull & Ebner-Priemer, 2009). The later issue underpins the attention afforded in the present study to motivation and habit-formation as the theoretical constructs behind this study's second aim – predictors related to *why* participants adhere to the EMA.

However, the broad hypothesis that autonomous motivation would be positively associated with adherence (Ryan & Deci, 2006) was only partially supported.

Results were varied; showing no evidence that the most autonomous form of motivational orientation – intrinsic motivation, as indicated by *Interest-Enjoyment* on the Intrinsic Motivation Index (IMI; H2a) – contributes to adherence. Conversely, the autonomous form of extrinsic motivation – *Value-Usefulness* (H2b) – is strongly positively associated with adherence to EMA. Other IMI subscales more closely related to controlled forms of extrinsic motivation – *Perceived Competence*, *Effort-Importance* or *Pressure-Tension* – are not associated with adherence, as anticipated by SDT (Ryan & Deci, 2006).

Taken together, these findings present theoretical implications for future EMA studies that might look to better understand the relationship between motivational orientation and adherence. Specifically, the notion that individuals who identify with and integrate the value of EMA with their personal goals are more likely to adhere. Moreover, SDT recognises motivation as pliable in relation to specific behaviours (Friederichs, Bolman, Oenema, & Lechner, 2015). Therefore, in the context of EMA adherence, motivational orientation may be manipulated with a view to initiating and sustaining adherence. Consequently, there are important practical implications for the design of EMA protocols to address adherence. This might be achieved by re-orienting individuals towards *Value-Usefulness* autonomous forms of extrinsic motivation, rather than focussing on the *Interest-Enjoyment* intrinsic motivational aspects of EMA design, such as aesthetics, which were shown not to influence adherence.

Turning to habit-formation, there was no support for the third hypothesis (H3) that automaticity moderates the association between motivation and adherence. This result contradicts previous findings that habit-formation through automaticity moderates the intention-behaviour relationship, i.e. motivation (Rothman et al., 2009). However, this may



be because the 14-day EMA protocol under investigation may not have been sufficient in length to elicit habit-formation, or, again that the study was under-powered to detect potentially small habit-formation effect sizes.

*Aim 3: Barriers, facilitators and experiences*

The themes identified as part of the qualitative analysis revealed valuable characteristics of participant's motivations, in addition to barriers and facilitators related to adherence with EMA. For instance, respondents indicated that their motivation for participating in the EMA was driven by *insights, self-awareness, personal health outcomes* and *interest* and, to a lesser extent, aspects of the *technology* itself and *feedback* from the EMA tool. These themes generally validate the quantitative data that emphasised *Value-Usefulness* as a predictor of adherence; moreover, they allow for a finer distinction of the most salient issues for participants.

A range of reasons for non-adherence or barriers to adherence were offered. One of the most frequently cited was *forgetfulness*, with a related concern being the inconvenience and *repetitiveness* of completing the same EMA questions every day. However, the use of facial emoticon scales in the EMA items may have played a critical role in compensating for this inconvenience (Roster, Lucianetti, & Albaum, 2015). Previous studies suggest that using face emoticons demands less cognitive effort, is less burdensome when interpreting EMA items (McKinley, Coote, & Stein-Parbury, 2003), and makes participation in EMA more enjoyable (Derham, 2011). Participants in this study reported that they "*liked the ease of use*" of the EMA and that "*it was easy and visually appealing*". Therefore, the use of a face emoticon scale in this study may have acted to reduce the burden of EMA and increase its feasibility among the young sample.

Furthermore, it was evident that participants could recognise the value and usefulness of self-monitoring their mental-health symptoms – as highlighted by the permeating themes of *insight* and *self-awareness* (Table 10). In this respect, the present study provides qualitative support to the empirical results that EMA is likely to appeal to young people who internally assimilate its personal value. Participant statements support research by Hetrick et al. (2017), who describe the feasibility of an EMA tool to monitor depressive symptoms in young people. The general sentiment from participants in the present study also raises the possibility that EMA can encourage the open disclosure of sensitive information in young people (Bradford & Rickwood, 2015), and overcome the reluctance of young people to seek help (Slade et al., 2009) as a means to manage their own mental-health.

### **Limitations and strengths**

This study has some limitations in addition to those noted (e.g. sample size), that must be acknowledged. First, participant self-selection into (or out of) this observational study influences the generalisability of findings and possibly has implications for interpreting results that refer to individual differences. A second related limitation stems from the lack of true experimental control in this study. As such, no causal inferences can be made from the reported results. Methodologies employed in future research could establish clearer cause-effect relationships by incorporating control groups.

Third, this study, as with most empirical adherence studies, calculated total EMA entries (activeness) without considering that overall adherence levels can decrease (or even increase) over time. Subsequently, Kim et al. (2016) recommend an alternate perspective on measuring adherence; treating it as a multidimensional construct that consists of not only activeness, but also timeliness and persistence (adherence over the entire protocol). By

incorporating such dimensions, a more complete adherence measure might more accurately capture time effects over both short- and longer-term EMA protocols.

Despite the stated limitations, the present study contributes to research on adherence in important ways. Notable, this study uniquely investigated motivation and habit-formation within established theoretical frameworks. Consequently, perhaps the most important discovery resulting from this study is the differentiation between intrinsic and autonomous extrinsic motivation – the latter a predictor of adherence.

In addition, the present study adopted a mixed-methods approach for the collection of richer data to direct future research in relation to adherence. The mixed-method in this study produced a degree of overlap across the quantitative and qualitative data that adds validity to the conclusions drawn from the statistical analysis. Therefore, despite the need for additional, well-controlled random trials in adherence research within e-health, such studies may neglect important qualitative feedback. Future work would benefit from continuing to elicit and report qualitative feedback regarding participant experiences and the utility of EMA owing to the multi-factorial influences on adherence.

Finally, the recruitment of a purposive sample of ‘at-risk’ young people via ReachOut with mostly *moderate* to *severe* scores on psychological distress measures (DASS21) was another prominent strength of this study. Whilst some e-health studies have found that low mood, anxiety and stress, is negatively associated with adherence to online interventions (Christensen et al., 2009), others have found considerably higher adherence in psychologically distressed than in non-clinical populations (Wenze, Arney, & Miller, 2014). The present study adds to this literature by noting that stress is positively associated with adherence and there is no association for anxiety or depression despite the high baseline

levels in the study sample; a promising outcome for the feasibility of EMA in individuals with pre-existing mental-health disorders.

### **Future research directions**

Given the importance of motivating young people to self-manage mental-health disorders and inform early interventions, additional future research directions, beyond those previously noted, are warranted.

It is worthwhile to first address the interesting non-linear effects in this study, whereby, the high adherence group recorded consistently lower scores on several motivational orientation (IMI) measures than the group categorised as medium. A distinguishing feature is that an increase in motivational orientation scores no longer results in an increase in adherence, but rather has the opposite effect. Although, the reason for this ‘inverted-U’ pattern is unclear, it could be argued that additional moderating factors may exist for individuals with high adherence to the EMA. Future research is needed to explore additional factors that moderate the relationship between motivational orientation and adherence, particularly if these include habit-forming factors not revealed in the present analysis.

In this study, *forgetfulness* emerges as a prevalent barrier to adherence, with issues around *reminders* frequently cited regarding this theme. Subsequently, future initiatives may investigate repetition, burden and user forgetfulness in the motivation-adherence relationship. For example, recent promising studies have embraced technology that unobtrusively records EMA from smartphone data-streams as proxy markers of mental-health symptoms, such as usage statistics as indicators of social activity (Place et al., 2017). These emerging technologies are well-placed to reduce the overall burden of self-report EMA.

One other direction for future research may be to pursue behavioural learning theories that advocate the use of cues (i.e. reminders) to modify unintentional non-adherence (Leventhal & Cameron, 1987). For instance, recent human-smartphone interaction research into receptivity and interruptibility is one emerging field that focusses on predicting opportune moments to effectively remind individuals with both useful and relevant prompts when competing for user attention (Fischer et al., 2010; Mehrotra, Hendley, & Musolesi, 2016). Although the present study was unable to clarify individual preferences for contextual cues, other studies have identified that users prefer to receive notifications, when they are in certain places and while engaged in certain activities (Mehrotra et al., 2017). Consideration of these findings is fundamental from an EMA design perspective. It allows for the optimisation of reminder mechanisms and sampling frequencies through the use of smartphone applications to maximise adherence and promote habit-formation (Ho, Balaji, Nikzad, & Srivastava, 2017).

An observation of SDT, and a notion supported by the results of this study, states that unmet expectations render individuals without motivation to behave. Further to this, indifference towards an activity – lack of value or interest – creates another source of amotivation (Ryan, Patrick, Deci, & Williams, 2008). This may, in part, be due to the overlooked or disregarded value of the EMA activity and its outcomes. The present study therefore underscores the potential importance of both informative and feedback mechanisms within EMA designs that contribute to increasing the perceived and actual Value-Usefulness motivational orientation. Future research could look to improve adherence to EMA by supporting the identification of personally meaningful goals and values, and by promoting the benefits of self-management; explicitly addressing the psychological need of autonomy, which demonstrates promise in improving mood and anxiety disorders (Barlow et al., 2002).

Whilst previous studies have reported that users are prepared to use e-health for managing mental-health issues (e.g. Burke et al., 2017), it remains a possibility that initial adherence diminishes after a period of time; contributing to the noted ‘law of attrition’ (Eysenbach, 2005). Longitudinal studies adopting EMA protocols in real-world settings are needed in order to understand the relationship of adherence with motivation and how it influences mental-health outcomes over time. Such studies would also be better placed to consider habit-formation and its moderating influence over motivation, adherence and mental-health outcomes.

Finally, an appealing aspect of e-health is the capacity to use algorithms to tailor interventions to individual preferences (Short et al., 2017). Rather than adopting traditional universal approaches to managing mental-health, e-health is well-placed to focus on individuals with diverse needs, and develop tailored interventions based on these individual differences. In much the same way that personality may be profiled, it may also be possible to profile an individual’s motivational orientation (Friederichs et al., 2015). Therefore, future EMA approaches, and the interventions informed by EMA, may be tailored not only by personality profiles but also by motivational profiles defined in this study in relation to EMA adherence.

## **Conclusion**

The present mixed-methods study lays important groundwork for future research in identifying and understanding factors that influence adherence to EMA protocols in distressed young people. This is particularly constructive since promising e-health technologies, such as EMA, generate unique data and bring unique challenges. For instance, they raise questions about “who is appropriate for this type of data gathering?” and “how to ensure that accurate data to inform early interventions is regularly reported?”. However,

answering these questions requires well-designed studies to formulate robust recommendations on technology design improvements and methodological changes to e-health EMA protocols. By bringing attention to motivational aspects of self-determination theory, one promising avenue offered by this study is to enhance the sense of value and usefulness of EMA – possibly by helping individuals understand why their recorded data is meaningful and how it might contribute to positive mental-health outcomes. Future research should continue to consider individual differences, including self-determination and habit-formation, to adequately address and maintain adherence over time.

For healthcare professionals, EMA, due to its appeal to young people, is a feasible consideration in the prevention and management of mental-health conditions. This study serves as a stepping stone toward continued research aimed at testing and uncovering new methods of improving adherence to optimise the effectiveness of EMA. This is important given the role of adherence in the accuracy of self-monitored EMA data (Kim et al., 2016), and the capacity for EMA to inform early and just-in-time interventions (Nahum-Shani et al., 2016) that are facilitated by this data. Overall, this study represents a valuable contribution in identifying which personality and motivational orientation correlates influence adherence to EMA in distressed young people. The next logical step is to use the theoretical knowledge of these mechanisms to design EMA protocols and associated effective interventions that attend uniquely to what motivates individuals and who is most likely to adhere to and subsequently benefit from them.

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## Appendix 1: Baseline Questionnaire

We are seeking participants aged between 18 to 25 years living in Australia to participate in a research study about how health apps and wearable devices can be used to support young people's mental health and wellbeing.

We will track your health by monitoring your behaviour in order to identify what elements will make you more likely to use these apps, and see if they can improve your health in the long term.

You will be asked to complete 2 online surveys (one at the beginning and the second after 6 months). We will ask you about your health in general including how you are sleeping, feeling, and what activities you usually do.

Once you complete the second survey you will receive a \$20 gift voucher from Coles-Myer.

This study is voluntary and anonymous, and only the researchers will have access to your details. We do require some contact details to send you reminders about the follow-up surveys and your gift voucher, but we will NEVER share these with anyone.

Sometimes answering questions about yourself can be upsetting. You can refuse to respond to any question. If you need someone to talk with you can contact Lifeline on 131114, Kids Helpline 24/7 on 1800 55 1800 or go to [www.kidshelp.com.au](http://www.kidshelp.com.au) for free online counseling.

Click [here](#) to view the full participant information sheet and to learn more about the study.

**Q0 Do you agree that you have read and understood the above information and provide your consent to participating in this study?**

Yes (1)

**Q1 Name**

**Q2 Date of Birth** (in the format: dd/mm/yyyy)

**Q3 What is your email address?** Note that we will only use this to send you a reminder with a link to complete the next part of the survey and to send you a voucher at the end of the study.

**Q4 What is your mobile number?** Note that we will only use this to send you a reminder TXT message with a link to complete the next part of the survey.

**Q5 Are you...**

- Male (1)
- Female (2)
- Other (3)

**Q7 Please tell us your postcode**

**Q10 What is your highest level of education**

- No formal education (1)
- Completed or partially completed primary school (2)
- Completed or partially completed junior high school (3)
- Completed or partially completed senior high school (4)
- Certificate or Diploma (5)
- Degree (6)
- Post Graduate Diploma, Masters or PhD (7)
- Refused (9)

**Q11 Which of these best describes your main activities?**

- Full-time work greater or equal to 30 hours paid employment per week (1)
- Part-time work less than 30 hours paid employment per week (2)
- Unemployed/looking for work (3)
- Home duties (4)
- Have a job, but not at work due to illness, vacation, etc (5)
- Not working and currently receiving sickness allowance/disability pension (6)
- Volunteer work (7)
- Student attending school (8)
- Student attending university (9)
- Refused (11)

**Q12 Please tell us your height (cm):**

**Q13 Please tell us your weight (kg):**

**Q23 How well do the following statements describe your personality?**

I see myself as someone who ...

	Disagree strongly (1)	Disagree a little (2)	Neither agree or disagree (3)	Agree a little (4)	Agree strongly (5)
Is reserved (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is generally trusting (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tends to be lazy (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is relaxed, handles stress well (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is outgoing, sociable (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tends to find fault with others (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Does a thorough job (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Get nervous easily (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Has an active imagination (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



**Q25 Please read each statement and chose the statement applied to you over the past week.**  
There are no right or wrong answers. Do not spend too much time on any one statement.


	Did not apply to me at all (1)	Applied to me to some degree, or some of the time (2)	Applied to me to a considerable degree, or a good part of the time (3)	Applied to me very much, or most of the time (4)
I found it hard to wind down (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was aware of dryness of my mouth (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I couldn't seem to experience any positive feeling at all (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to work up the initiative to do things (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I tended to over-react to situations (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I experienced trembling (e.g. in the hands) (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was using a lot of nervous energy (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was worried about situations in which I might panic and make a fool of myself (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Did not apply to me at all (1)	Applied to me to some degree, or some of the time (2)	Applied to me to a considerable degree, or a good part of the time (3)	Applied to me very much, or most of the time (4)
I felt that I had nothing to look forward to (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found myself getting agitated (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to relax (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt down-hearted and blue (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was intolerant of anything that kept me from getting on with what I was doing (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I was close to panic (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was unable to become enthusiastic about anything (16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I wasn't worth much as a person (17)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was rather touchy (18)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat) (19)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt scared without any good reason (20)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt life was meaningless (21)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q57 Thank you for completing the first survey!

If you are feeling distressed or upset, please ask for help.  
Call Kids Helpline on **1800 551 800** or Lifeline on **13 11 14**.

## Appendix 2: EMA Protocol Instructions



### Health Tracking Setup

We also have developed an additional website which quickly and easily tracks your mood, sleep, exercise and diet in order to give you an accurate snapshot of your overall health. Over the next 2 weeks we will send you daily emails to log in and answer questions on: Exercise, sleep, mood, diet. These will only take around 30 seconds per day to complete. You will then receive a personalised health report at the end of the 2 weeks. Your report will give you a unique picture of how your daily mood, sleep, exercise and diet affect each other.

In addition to using your selected health app/s for the next 2 weeks, we also really want you to use this resource. We are really interested in relating your app data to your daily mood, sleep, exercise and diet information, in order to give you a detailed and useful picture of your overall health. Although it would be great if you could enter this data every day, you will still be eligible for your \$20 reward if you log in and complete the health tracking questionnaire a **minimum of 8 times over the next 2 weeks.**

---

What is your preferred time of day to complete these questions?

[Next](#)

### Appendix 3: Follow-up Email

Hi [\\$FirstName](#)

We are contacting you because you previously participated in an important online study conducted through ReachOut.com and now jointly coordinated by Flinders University and the University of Adelaide.

We really appreciate and value your contribution to our research, and would like to invite you to close out this study by completing this final follow up survey that you consented to. The survey should only take 5-10 minutes. Your details and all collected data will remain confidential and used only within this study.

On completion of this survey you will receive a **\$20 gift voucher from Coles-Myer**.

**To complete the survey, click on the following link:**

[Take the Survey](#)

Or copy and paste the URL below into your browser:

[SurveyURL](#)



Many thanks,

**John Fouyaxis**



Follow the link to opt out of future emails:

[Click here to unsubscribe](#)


## Appendix 4: Follow-up Questionnaire

Thanks so much for sticking with us through this study and contributing to our research! Although it has been some time since the initial survey, we ask that you take the time to please complete this final and important follow up survey.


This follow up survey refers to the short daily assessment questions in the online tool that you may have registered for. If you recall, these questions asked about your mood, energy and sleep every day during a two-week period.

You were asked to move faces along a scale to match how you rated each of these three areas:


Move faces to match ...

 How are you **feeling** today?


very low   low   ok   good   great

 (positioned over 'great')


---

 How is your **energy** today?


very tired   tired   ok   energetic   very energetic

 (positioned over 'energetic')

---

 How well did you **sleep** last night?

very poorly   poorly   ok   well   very well

 (positioned over 'very well')

Since we value and appreciate your participation in our ongoing research, once you have completed this final survey about the daily assessment questions we will send you your \$20 gift voucher from Coles-Myer.

As a reminder... this study is voluntary and anonymous, and only the researchers will have access to your details. We do require some details to contact you about your gift voucher, but we will NEVER share these with anyone.

Sometimes answering questions about yourself can be upsetting. You can refuse to respond to any question. If you need someone to talk with you can contact Lifeline on 131114, Kids Helpline 24/7 on 1800 55 1800 or go to [www.kidshelp.com.au](http://www.kidshelp.com.au) for free online counseling.

Click [here](#) to review the full participant information sheet and to learn more about the study.

## Q2.1 Motivation

On the scale shown, please indicate how true you believe each one of the following statements are in relation to the short daily assessment questions that you completed.

	Not at all (1)	2 (2)	3 (3)	Somewh at true (4)	5 (5)	6 (6)	Very true (7)
I put a lot of effort into this. (Q9_1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would be willing to do this again because it has some value to me. (Q9_2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did this activity because I wanted to. (Q9_4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was pretty skilled at this activity. (Q9_5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt pressured while doing these. (Q9_6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought this was a boring activity. (Q9_7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe this activity could be of some value to me. (Q9_8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt like it was not my own choice to do this task. (Q9_9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I thought this activity was quite enjoyable. (Q9_10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think I am pretty good at this activity. (Q9_11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think this is an important activity. (Q9_12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I didn't put much energy into this. (Q9_13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This activity did not hold my attention at all. (Q9_14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was very relaxed in doing these. (Q9_15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did this activity because I had to. (Q9_16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would describe this activity as very interesting. (Q9_17)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Q3.1 Habits

On the scale shown, please indicate whether you agree with each of the following statements in relation to the short daily assessment questions that you completed.

**Completing the short daily assessment questions was something...**

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I did automatically. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did without having to consciously remember. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did without thinking. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I started doing without realising I was doing it. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



## Q3.2 Cues

To determine what helped you remember to complete the daily assessment questions, please indicate how true each of the following statements are about when you tended to complete the daily assessment questions.

**Each time I completed the short daily assessment questions...**

	Not at all (1)	2 (2)	3 (3)	Somewhat true (4)	5 (5)	6 (6)	Very true (7)
it was the same time of the day. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was around the same people. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was doing the same type of activity. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was in the same part of my daily routine. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was in the same place. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was in the same mood. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Q4.1 Your Experiences

Please tell us about your experience with these short daily assessment questions. There are no right or wrong responses; we are interested in your personal opinions. Simply list the thoughts that come immediately to mind.

**Why did you take part in the daily assessment questions?**

**Q4.2 What did you expect to gain from the daily assessment questions?**

**Q4.3 Did completing the daily assessment questions...**

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
meet your expectations? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q4.4 What did you like about the daily assessment questions?**

**Q4.5 What didn't you like about the daily assessment questions?**

--

Condition: Adherence >= 14 DAYS... Is True. Skip To: 5.3

Q5.1 Your Experiences (continued)

Our records indicate that you did not complete these short daily assessment questions over the two week period of the study. Please help us understand why by answering the following questions.

**What prevented you from completing the daily assessment questions every day for the two week period?**

**Q5.2 What would you suggest to increase the likelihood that you would more regularly complete the daily assessment questions every day across the two week period?**

--

**Q5.3 Please feel free to write additional comments about any aspects of your experience in taking part in the daily assessment questions for this study [OPTIONAL]**


## Appendix 5: Non-adherence Follow-up Questionnaire

Thanks so much for sticking with us through this study and contributing to our research! Although it has been some time since the initial survey, we ask that you take the time to please complete this final and important follow up survey.

This follow up survey refers to the short daily assessment questions in the online tool that our records indicate you *did not* register to complete. These questions asked about your mood, energy and sleep every day during a two-week period.

You would have been asked to move faces along a scale to match how you rated each of these three areas:

Move faces to match ...



How are you **feeling** today?


very low


low

ok

good

great





How is your **energy** today?


very tired


tired

ok

energetic

very energetic





How well did you **sleep** last night?


very poorly

poorly

ok

well

very well



Since we value and appreciate your participation in our ongoing research, we are still interested in your input. Once you have completed this final short survey about the daily assessment questions we will send you a \$20 gift voucher from Coles-Myer.

To begin the survey, click the NEXT arrow below...

As a reminder... this study is voluntary and anonymous, and only the researchers will have access to your details.

We do require some details to contact you about your gift voucher, but we will NEVER share these with anyone.

Sometimes answering questions about yourself can be upsetting. You can refuse to respond to any question. If you need someone to talk with you can contact Lifeline on 131114, Kids Helpline 24/7 on 1800 55 1800 or go to [www.kidshelp.com.au](http://www.kidshelp.com.au) for free online counseling.

### Q2.1 Your Experiences

Thinking about the daily assessment questions described above, please share your thoughts. There are no right or wrong responses; we are interested in your personal opinions. Simply list the thoughts that come immediately to mind.

**Why didn't you take part in the daily assessment questions?**

**Q2.2 What do you expect you may have gained from taking part in the daily assessment questions?**

**Q2.3 What would you suggest to increase the likelihood that you would participate in completing such daily assessment questions in the future?**

## Appendix 6: Power Analysis

**t tests** – Linear multiple regression: Fixed model, single regression coefficient

<b>Analysis:</b>	Post hoc: Compute achieved power	
<b>Input:</b>	Tail(s)	= Two
	Effect size $f^2$	= 0.02
	$\alpha$ err prob	= 0.05
	Total sample size	= 46
	Number of predictors	= 8
<b>Output:</b>	Noncentrality parameter $\delta$	= 0.9591663
	Critical t	= 2.0261925
	Df	= 37
	Power ( $1-\beta$ err prob)	= 0.1544554

**t tests** – Linear multiple regression: Fixed model, single regression coefficient

<b>Analysis:</b>	Post hoc: Compute achieved power	
<b>Input:</b>	Tail(s)	= Two
	Effect size $f^2$	= 0.15
	$\alpha$ err prob	= 0.05
	Total sample size	= 46
	Number of predictors	= 8
<b>Output:</b>	Noncentrality parameter $\delta$	= 2.6267851
	Critical t	= 2.0261925
	Df	= 37
	Power ( $1-\beta$ err prob)	= 0.7251275

**t tests** – Linear multiple regression: Fixed model, single regression coefficient

<b>Analysis:</b>	Post hoc: Compute achieved power	
<b>Input:</b>	Tail(s)	= Two
	Effect size $f^2$	= 0.35
	$\alpha$ err prob	= 0.05
	Total sample size	= 46
	Number of predictors	= 8
<b>Output:</b>	Noncentrality parameter $\delta$	= 4.0124805
	Critical t	= 2.0261925
	Df	= 37
	Power ( $1-\beta$ err prob)	= 0.9741939

**t tests** – Linear multiple regression: Fixed model, single regression coefficient

<b>Analysis:</b>	A priori: Compute required sample size	
<b>Input:</b>	Tail(s)	= Two
	Effect size $f^2$	= 0.02
	$\alpha$ err prob	= 0.05
	Power ( $1-\beta$ err prob)	= 0.95
	Number of predictors	= 8
<b>Output:</b>	Noncentrality parameter $\delta$	= 3.6110940
	Critical t	= 1.9636602
	Df	= 643
	Total sample size	= 652

## Appendix 7: Comparison of Means across Tertiles

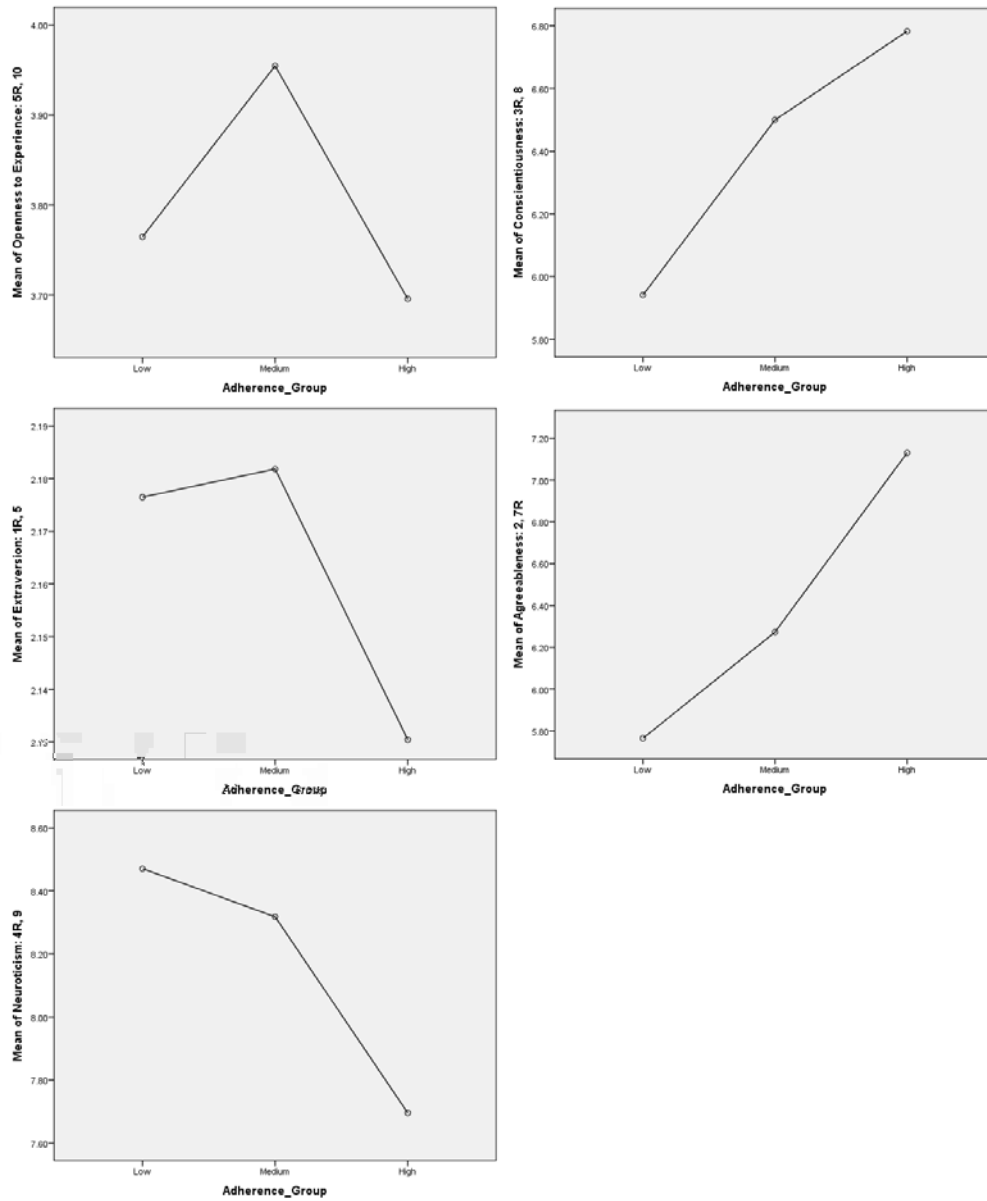


Figure A7.1. Mean plots of Personality scores across adherence tertiles

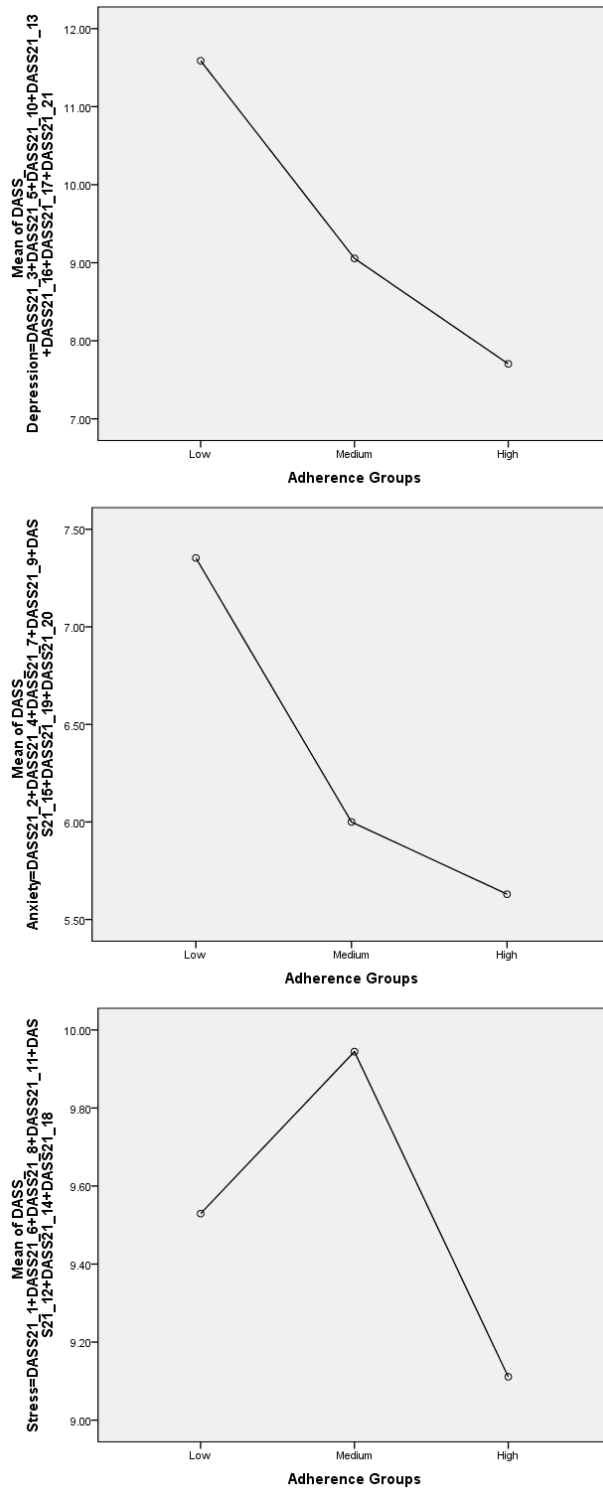


Figure A7.2. Mean plots of Psychological distress (DASS21) scores across adherence tertiles

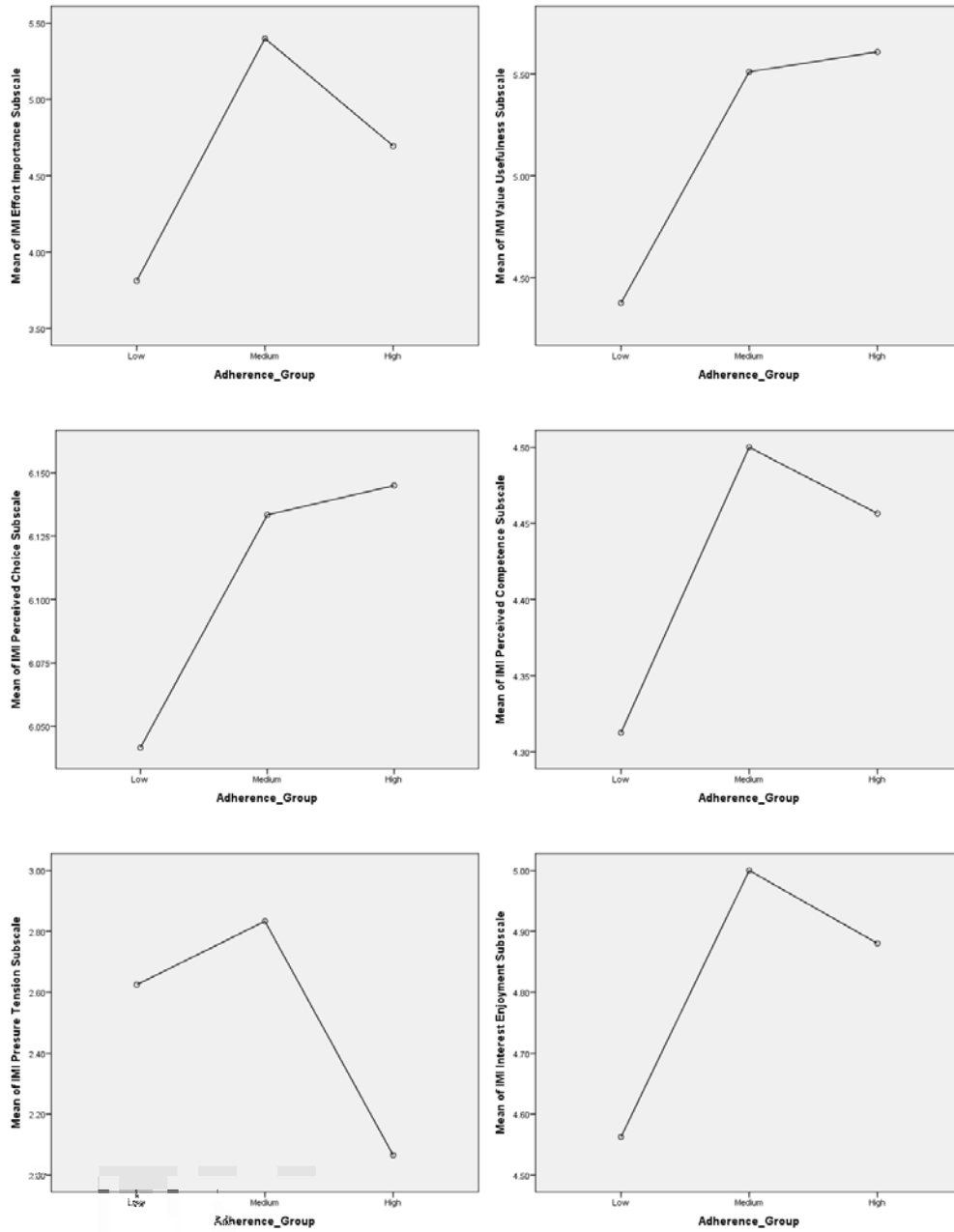
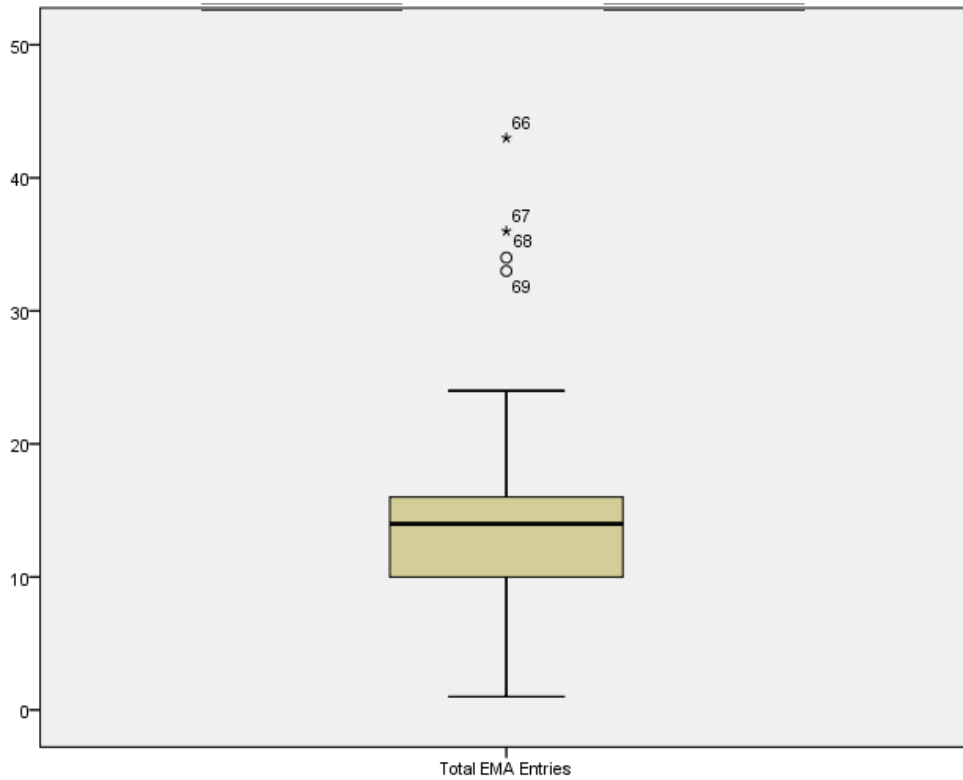


Figure A7.3. Mean plots of Motivational Orientation (IMI) scores across adherence tertiles



## Appendix 8: Assumption Tests



**Figure A8.1.** Boxplot analysis for outliers in adherence scores for EMA Protocol Follow-up Responders

**Table A8.1.** Test of normality before removing outliers

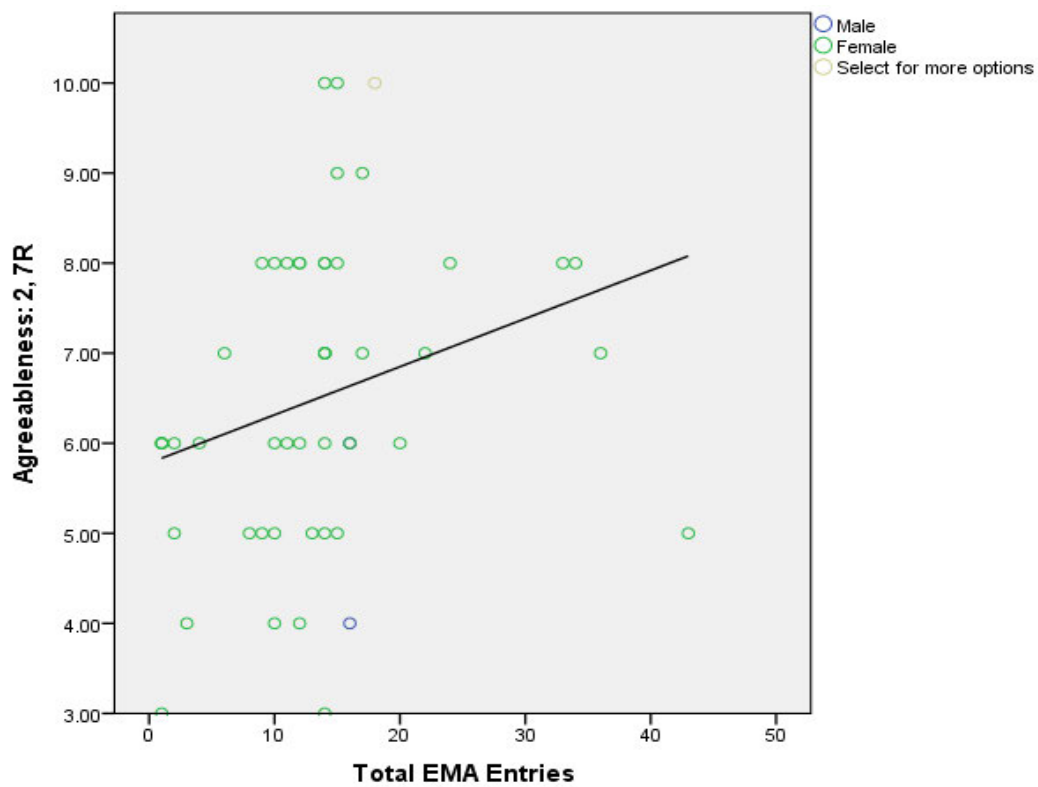
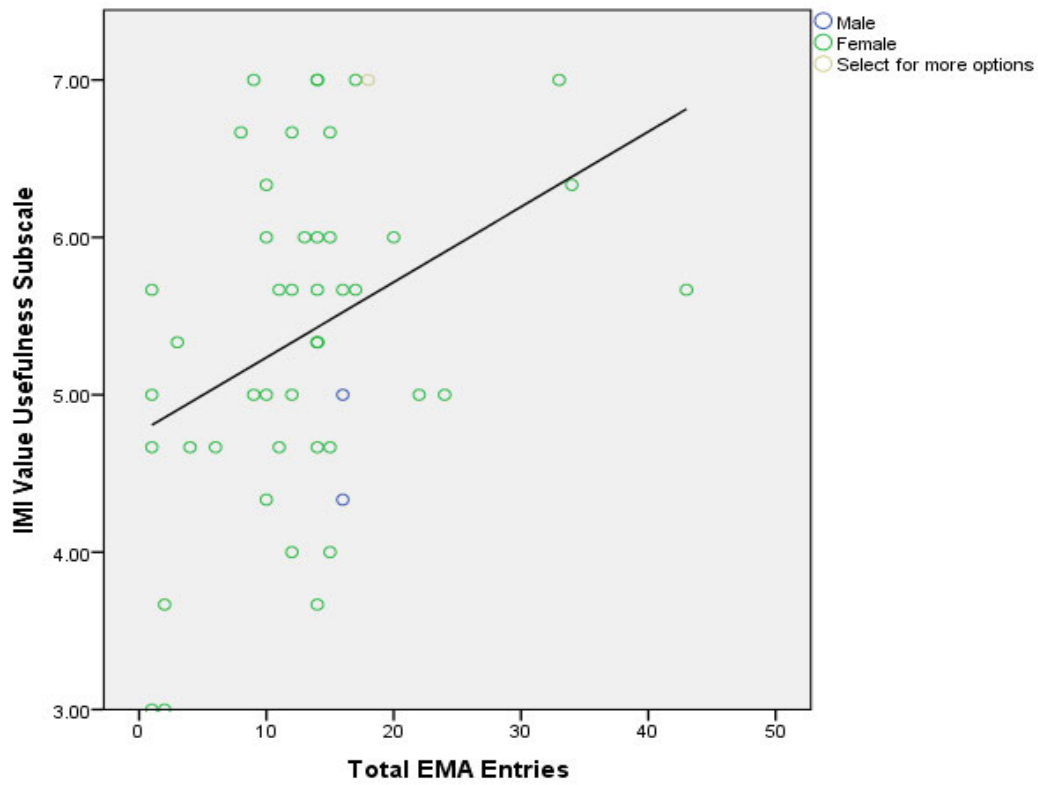
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	<i>p</i>	Statistic	df	<i>p</i>
Total EMA Entries	.191	49	.000	.874	49	.000

a. Lilliefors Significance Correction

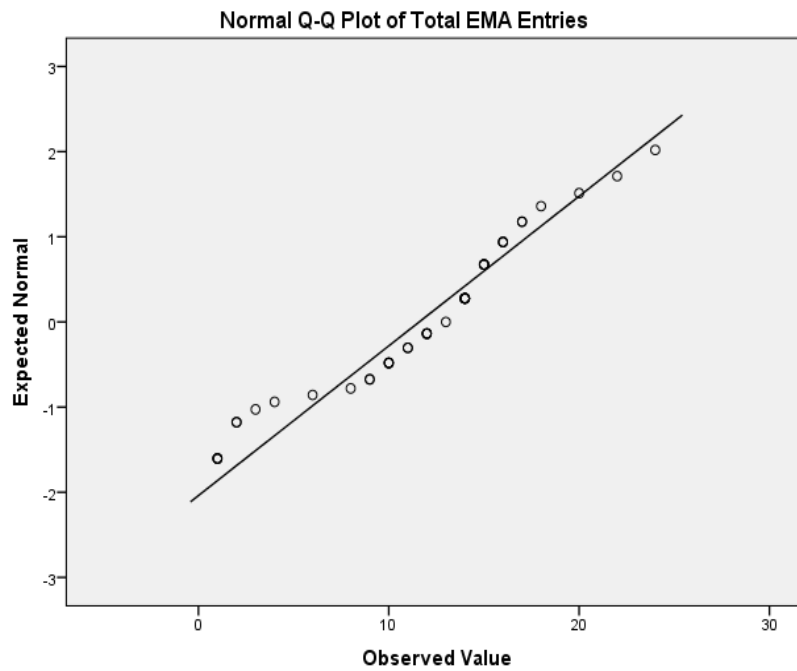
**Table A8.2.** Test of normality after removing outliers

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	<i>p</i>	Statistic	df	<i>p</i>
Total EMA Entries	.119	46	.105	.929	46	.008

a. Lilliefors Significance Correction



**Figure A8.2.** Scatterplot visual examinations for linearity and homoscedasticity. Examples for IMI Value-Usefulness and Agreeableness measures.



**Figure A8.3.** Q-Q plot visual examination of errors for normality of dependent variable (adherence).

**Table A8.3.** Collinearity statistics for model step 2

	Collinearity Statistics	
	Tolerance	VIF
Age (Years)	.850	1.177
Gender	.794	1.260
BFI-10 Agreeableness	.619	1.615
BFI-10 Conscientiousness	.766	1.306
BFI-10 Neuroticism	.671	1.491
DASS21 Stress	.262	3.817
DASS21 Anxiety	.243	4.115
IMI Value Usefulness	.494	2.024
IMI Interest Enjoyment	.516	1.937

## Appendix 9: SPSS Regression Command Syntax

### Linear Hierarchical Multiple Regression

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING MEANSUBSTITUTION
  /STATISTICS COEFF OUTS CI(95) R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Adherence
  /METHOD=ENTER Age Gender Agreeableness Conscientiousness Neuroticism
  DASS_Anxiety DASS_Stress
  /METHOD=ENTER IMI_VU_Subscale IMI_IEnj_Subscale
  /METHOD=ENTER IMI_EImp_Subscale IMI_PCo_Subscale IMI_PT_Subscale
  /METHOD=ENTER Habit_Total_Strength
  /RESIDUALS DURBIN HISTOGRAM(ZRESID) NORMPROB(ZRESID).
```

### Non-Linear Zero-Inflated Negative Binomial

```
STATS ZEROINFL
MODELSOURCE=ESTIMATE
DEPENDENT=Adherence
COUNTMODEL=Age Gender Agreeableness Conscientiousness Neuroticism
DASS_Anxiety DASS_Stress DASS_Depression
SAMEREGRESSORS=YES
COUNTDIST=NEGBIN ZEROLINK=LOGIT
/OPTIONS STARTVALUES=GENLIN OPTMETHOD=BFGS MAXITER=1000 TOL=0.0000000001
/SAVE WORKSPACEACTION=CLEAR.
```