The London School of Economics and Political Science

The Happy Wanderer: Exploring the relationship between thoughts and well-being

Luc Schneider

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Statement of co-authored work

I confirm that chapters 3 (paper 1) and 4 (paper 2) were jointly co-authored with Dr Sandra Buda, Dr Aleksandar Matic and Prof Paul Dolan. I contributed 70% of the work in both chapters.

I confirm that chapter 6 (paper 4) was jointly co-authored with Amanda Henwood, Dr Sandra Buda, Dr Aleksandar Matic and Prof Paul Dolan. I contributed 60% of the work.

Abstract

The relationship between what we think about and how we feel is central to the human experience. To understand this relationship is essential to the creation of impactful well-being enhancing interventions. In this thesis, we explore the relationship between thoughts and well-being, and we assess the impact of a simple well-being enhancing intervention. In chapter 1, we discuss how thoughts ought to be incorporated into models that outline the main determinants of well-being. We present a model that argues that thoughts are direct predictors of well-being, and that this relationship is moderated by individual-specific characteristics and contextual factors. In chapter 2, we present the experience sampling dataset that we use to explore this model in ecologically valid, day-to-day settings. In chapter 3, we explore the direct relationship between thoughts and well-being, showing not only that thoughts predict, but also that they can be said to cause changes in experiential measures of happiness and worthwhileness. In chapter 4, we explore how the direct relationship between thoughts and well-being is moderated by individual-specific characteristics. We show that the relationship between thoughts and our experiential measures of well-being is better captured when accounting for unobserved individual-specific factors, and that Big 5 personality traits can explain some of this individual-specific variation in the relationship between thoughts and experienced worthwhileness. In chapter 5, we explore how the relationship between thoughts and well-being differs depending on what activity people are engaged in and depending on who they are with. We show that context matters in terms of how people experience their thoughts. What people do and who they are with affect what kind of thoughts they report, as well as how these thoughts are associated with their well-being. Finally, in chapter 6, we assess the effectiveness of our experience sampling data collection tool as a well-being enhancing intervention in and of itself. We show that asking people to repeatedly report their thoughts, well-being and associated context reduces their anxiety across three different Randomised Controlled Trials. We discuss practical implications of this and of our exploration of thoughts and well-being for intervention designers, as well as implications for the broader well-being and thoughts literature.

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Motivation

What makes people happy? Four years ago, I was trying to answer that question, for myself. I had been applying to consulting jobs, because I imagined that that was what I was supposed to do after graduating with an MSc in Behavioural Economics. In those days, success looked a little like this: *graduate; get a good job; make money; get promoted; make more money;* and repeat that a few times. Possibly, *find a partner; settle down; have some children;* and live happily ever after. Success was, first and foremost, about acquiring the physical means to satiate all of our purchasable desires. It is still, broadly speaking, society's sales pitch for happiness. Here was my problem: that did not sound like happiness to me. I was stumbling at that first hurdle. The getting a "good" job part. Because the closer I got to any of them, the more certain I was that I would be miserable there.

I thought about happiness a lot, during those days. I was trying to understand why this commonly accepted path to happiness was good enough for my friends, but not for me. I do not remember exactly how I got to the answer. There was no *"Eureka!"* moment. The realisation came gradually: happiness exists (occurs) only inside of me, and it is composed of multitudes of small, day-to-day experiences. So, I brushed aside my initial plans for a career in consulting, and I decided to dedicate my time to the answering of this question: what *actually* makes people happy? That is how I ended up here.

When people ask me what my PhD is about, I tell them, first, that I study happiness. Then, that I study the relationship between what people think and how they feel. Occasionally, one of them asks me why. I have an answer for that too: I study thoughts and feelings because I believe that they encompass our entire experience of reality. Everything that we can possibly communicate, everything that we are aware of, is captured in our thoughts and feelings. They are what "being human" is.

All I really hope to do, here, is contribute even the smallest fraction to our understanding of what that entails.

Thesis aims and outline

This thesis broadly tries to answer two questions, across four overarching aims. The first question is: what is the relationship between thoughts and well-being? The second: can asking people to report what they are thinking about and how they feel improve their well-being? The overarching aims behind these questions are to better understand the internal determinants of well-being, while exploring possible well-being enhancing interventions in the process. Specifically, we aim to (1) *explore the association between different components of thoughts and well-being;* (2) *understand how individual-specific characteristics and context affect the relationship between thoughts and well-being;* (3) *provide an overarching framework that clearly outlines the relationships between thoughts, well-being and its other known determinants, to serve as a reference point for future research in the field;* and (4) *assess whether the act of repeatedly reporting thoughts and well-being for data collection purposes can also be used as a well-being enhancing intervention.*

To address these questions and aims, this thesis is composed of a theoretical framework that breaks down the existing literature on well-being and thoughts and introduces the model that we propose to study their relationship through, and four empirical papers that each focus on one of the abovementioned aims. The first three papers, presented in chapters 3 to 5 all explore the relationship between thoughts and well-being. The fourth paper (chapter 6) brings together three studies that look at how repeatedly reporting one's thoughts and well-being might impact one's well-being.

In paper 1 (chapter 3), we explore the relationship between thoughts and well-being in general. We split thoughts into type (i.e., whether a thought is related to the current activity, or whether it is a form of mind wandering), content (i.e., what the temporal orientation of the thought is, and who it is directed towards) and valence (i.e., whether a thought is positive, neutral or negative), and we investigate whether interactions between these components predict experiences of happiness and worthwhileness. We also establish causal links by looking at whether lags of these components of thoughts can predict well-being over and above lags of our well-being variables.

In paper 2 (chapter 4), we look at whether the relationship between type, content and valence of thoughts and well-being is moderated by personality, or individual-specific characteristics in general. We use multi-level models including random slopes to check

whether the relationship between our thought variables and experienced happiness and worthwhileness is better predicted when accounting for individual differences.

In paper 3 (chapter 5), we extend the work done in paper 1 to account for different contexts, in terms of what people are doing and who they are with. We run fixed effect models using type, content and valence of thoughts on sub-samples of the most frequently reported activities and types of company in our dataset. We also compare the report rate of every thought component across these activities and types of company.

In paper 4 (chapter 6), we bring together the data of three large-scale Randomised Controlled Trials (RCT) in which participants were randomly assigned to a treatment where they were asked to report what they thought about, how they felt, and the context of these internal experiences, or a control where they were either asked to report on context only or waitlisted. We use pre- and post-RCT measures of well-being in each study to determine whether reporting thoughts and well-being can actually improve participant well-being.

The formatting of each paper differs according to the journal it is currently under review at. Paper 1 presented in chapter 3 is currently under review at the *Journal of Experimental Psychology: General.* Paper 3 (chapter 5) is currently under review at *Emotion*. Paper 4 (chapter 6) is currently under review at *Scientific Reports*. Paper 2 (chapter 4) is being prepared for submission to the *Journal of Personality*.

Chapter 1: Theoretical Framework

In recent decades, attempts by social scientists to uncover the determinants of individual well-being have focused on the empirical investigation of various economic and psychological factors (see Diener et al., 1999; Dolan et al., 2008). Developments in the field, both in terms of how we define well-being and in terms of empirical evidence, have led to an increased interest for well-being enhancing policies in public spheres. As the scientific community has started to recommend the use of these well-being measures in policy implementations (Diener et al., 2018; Dolan & Metcalfe, 2012; Frey & Stutzer, 2012), the study of the external and internal mechanisms that influence our well-being has gained tremendous importance.

To this end, several models explaining variations in well-being have been proposed (e.g., Dolan, 2014; Lyubomirsky et al., 2005). Lyubomirsky et al. (2005) argue that well-being (specifically, happiness) is determined by three main factors, namely, genetic and individual-specific characteristics, circumstances, and activities. More specifically, they assign 50% of the variance in happiness to genetic and personality traits and 10% to circumstances, as suggested by earlier literature (Diener & Lucas, 1999; Lykken & Tellegen, 1996), and they make the case that the remaining 40% ought to be captured by *behavioural, cognitive* and *volitional* activities. They claim that these three types of activities are essential to capture within-person variation in happiness, and that taking this variation into consideration is necessary to reach a more complete understanding of well-being in general.

In the meantime, the relationship between observable behaviours and well-being has been extensively studied in the context of well-being enhancing interventions (e.g., Lally & Gardner, 2013; Sin & Lyubomirsky, 2009). The relationship between activities of the cognitive kind and well-being has also been explored at length, particularly in clinical and experimental settings (e.g., Mrkva et al, 2019; Roberts & Danoff-Brug, 2010). Less is known, however, about how specific cognitive activities, such as thoughts, are related to well-being in day-to-day settings, and how this relationship may be leveraged in targeted interventions. While Lyubomirsky et al.'s (2005) three-factor model does well to categorise the main determinants of happiness and to draw attention to the importance of studying both between- and within-person variance, it does little to explain how individual-specific characteristics and other contextual variables may affect how people react to such cognitive activities as they

go about their daily lives. In the present thesis, we explore these questions by diving deeper into the relationship between thoughts and well-being, as well as how this relationship varies depending on people's personality and contextual factors, like what they are doing and who they are with.

Overarching model

Within the social science tradition, different facets of well-being are often discussed under the overarching construct of *subjective well-being* (SWB), which is often understood as having a cognitive and an affective dimension, consisting of life satisfaction, and positive and negative affect, respectively (Busseri & Sadava, 2011; Pavot & Diener, 2009). More recent work by Dolan and colleagues has extended this definition to explicitly account for a purpose component of SWB (Dolan, 2014; Dolan & Kudrna, 2016; Dolan & Metcalfe, 2012). As such, SWB captures both experiential and evaluative assessments of well-being. Throughout this thesis, we are interested first and foremost in experienced SWB – that is, people's affective states and the sense of purpose they feel in the moment of reporting – and how those relate to people's thoughts.

To date, the body of social science literature that discusses the relationship between thoughts and well-being has focused predominantly on the distinction between mind wandering and on-task thoughts (Schooler et al., 2014; Smallwood & Andrews-Hanna, 2013; Smallwood & Schooler, 2015). In ecologically valid settings, these thoughts have been shown to make up around 40% of all thoughts, and to account for more variation in happiness than activities (Killingsworth & Gilbert, 2010). In line with the literature, we distinguish between several components of thoughts, including type, valence and content, all of which play a role in determining well-being (Andrews-Hanna et al., 2013; 2014). We specifically focus on mind wandering defined as thoughts that arise when attention is directed or drawn away from the current activity or task, as opposed to thoughts related to current activity (as in Franklin et al., 2013; Killingsworth & Gilbert, 2010; Welz et al., 2018). We argue that our understanding of the relationship between mind wandering and well-being currently lacks depth and nuance, and that the study of type, valence and content of thoughts in conjunction with the aforementioned individual-specific and contextual factors can help clarify this relationship.

In addition, Smallwood and Andrews-Hanna (2013) formulated content- and context-regulation hypotheses to acknowledge that the relationship between mind wandering and

well-being should depend on both the specific content of the thoughts and the context within which they occur. Despite this, no model to date incorporates the relationship between thoughts and well-being within broader models of well-being, and there is little evidence around how this relationship changes depending on individual-specific characteristics and on the context within which a person reports what they are thinking about and feeling.

In the present thesis, we propose a model that builds upon the known determinants of well-being while highlighting the importance of thoughts at the centre of it. In line with Lyubomirsky et al.'s (2005) model, we distinguish between (1) individual-specific characteristics such as personality, and (2) contextual factors, including observable activity-related variables. While there is extensive evidence for the effect of both these individual-specific characteristics and contextual factors on well-being, we make the case that these factors also affect the way people react to their thoughts, and that thoughts themselves are an important determinant of both within- and between-person variation in well-being. Figure 1 illustrates the proposed model, for which we will provide a theoretical framework and supporting evidence in this chapter.
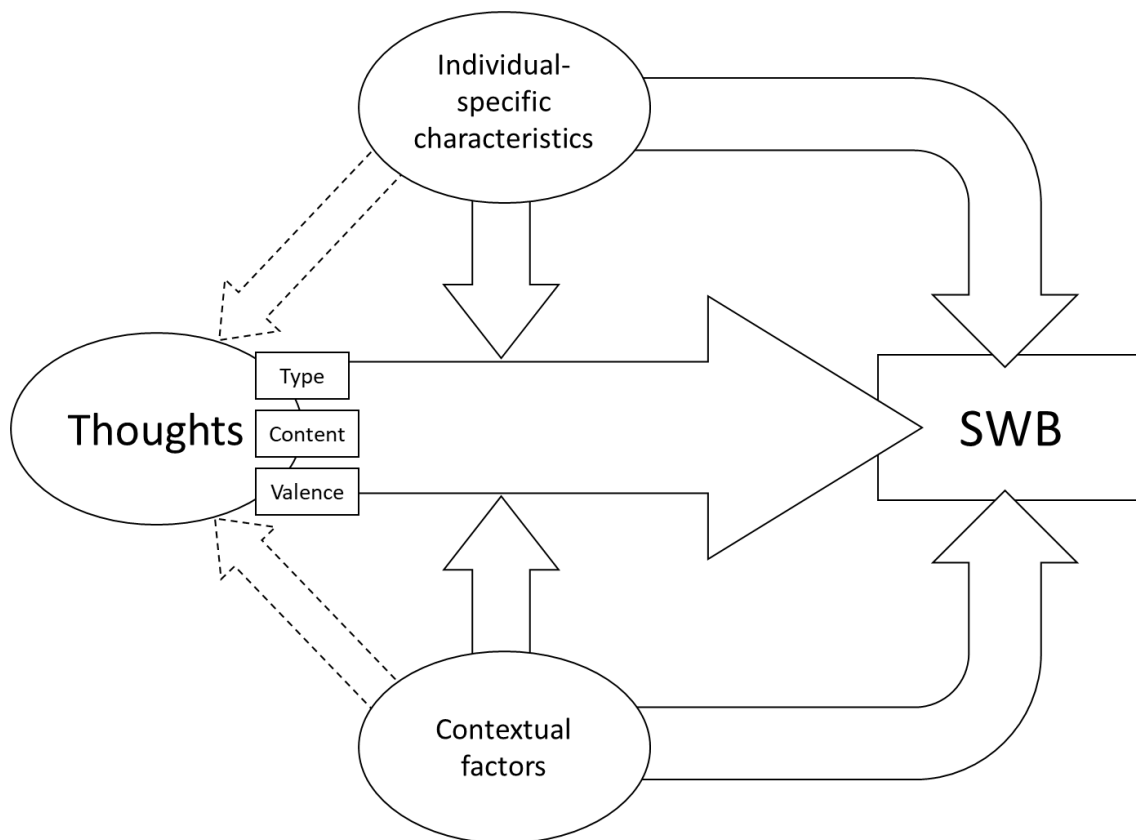
Figure 1: Graphical visualisation of the proposed thoughts model of well-being. Note: arrows are unidirectional for simplicity, and merely aim to illustrate the relationships that are directly meaningful and relevant for the present thesis.

The underlying intuition behind this model is that the 40% of the variation in well-being that Lyubomirsky and colleagues (2005) attribute to "activities" are really a function of what we pay attention to. That is to say that whether our attention is directed *outwards* or *inwards* will play a crucial role in determining how we feel. We already know that what we pay attention to affects both our holistic assessments of well-being (Dolan & Powdthavee, 2012) and momentary emotional experiences (Mrkva et al., 2019; 2020). Studying thoughts provides us with the opportunity to get deeper insights into where people direct their attention, both in terms of whether people are paying attention to their external circumstances and what they are actually thinking about when their attention is directed inwards.

Following this model, the aims of the present thesis are threefold: (1) to explore the association between different components of thoughts and well-being; (2) to understand the weight and importance of this association relative to the individual-specific and contextual determinants of well-being as portrayed above; and (3) to determine how individual-specific characteristics and contextual factors affect the thoughts that people report and how those relate to their experienced SWB. In addition, we discuss one potential mechanism through which repeatedly reporting one's thoughts, context and well-being might be used as an intervention of improve people's overall well-being.

In this theoretical framework, we address the literature underlying the aforementioned model and aims. First, we discuss the different approaches to the study of well-being to highlight the variables that will be used in later chapters of this thesis and cover the existing evidence on the relevant determinants of well-being. Second, we elaborate on how we define thoughts, in terms of human cognition and consciousness, in the context of the studies presented in this thesis. In doing so, we review how different social sciences have defined thoughts and their components to measure and quantify them, while also going over how these components of thoughts are related to people's well-being. Finally, we provide a more detailed overview of how this thesis aims to expand our current understanding of the relationship between thoughts and well-being, and how this might subsequently be incorporated into interventions.

Subjective well-being

Philosophical background

Throughout history, philosophers have recognised three general approaches to look at well-being: (1) mental states theories, (2) desire fulfilment theories and (3) objective list

theories (Parfit, 1984). Mental state theories of well-being are characterised by the notion that well-being is reliant on a certain mental state. That is, well-being is driven by internal processes and experiences (Kawall, 1999), and cognitive, affective, attentional and emotional states are central to the pursuit of well-being (Crisp, 2006; Haybron, 2016). The most prominent of these mental state theories, hedonism, is characterised by the pursuit of pleasure over pain (see Bentham, 1789; Mill, 1863, for utilitarian hedonism).

Desire-fulfilment theories of well-being focus on the attainment or acquisition of what the individual desires (Bailey, 2009; see Gasper, 2007; Heathwood, 2016 for a more in-depth discussion), while objective list theories look at well-being as the satisfaction of a set of objective conditions that would increase one's well-being regardless of tastes, traits or interests (e.g., Fletcher, 2013; Griffin, 1986).

When looking at how these theories ought to be applied in reality, each approach is recognised as serving different purposes in different contexts (Scanlon, 1993). In the present thesis, we draw from mental state theories by focusing on experienced pleasure (or happiness) and purpose (or worthwhileness), as well as life satisfaction and anxiety into our measures of well-being, and by endorsing the view that the individual experience of well-being is driven first and foremost by one's internal cognitive, affective, attentional and emotional processes. As such, our approach to the study of well-being is in alignment with the developments in social science literature in the past decades, where the focus has been on subjective well-being.

Definition

The notion of subjective well-being (SWB) in social sciences initially emerged from the recognition that well-being is made up of two distinct components: a cognitive and an affective one (Busseri & Sadava, 2011; Pavot & Diener, 2009). The cognitive component, which is captured by measures of life satisfaction, is evaluative, while the affective component, which is captured by measures of positive and negative affect, is experiential. These two components, and the three measures that capture them, are still central to the way we define and understand SWB today.

This working definition, which is the one used in Lyubormisky et al.'s (2005) model, is the one that has been applied in the vast majority of the literature in the past decades. However, Dolan (2014) argues that SWB is best captured when taking into consideration an additional component of purpose, adding a necessary experiential and evaluative component

to the overall construct (Dolan & Metcalfe, 2012). While purpose had already been extensively discussed as an evaluative measure of well-being (see Ryff, 1989; 2014), Dolan and colleagues (2009; 2012; 2016) highlight the importance of capturing momentary experiences of purpose as well. They argue that people can be driven by purpose both in the broader context of their lives (in which case it might feed into life satisfaction) and in its momentary pursuit (i.e., engaging in an activity because it feels purposeful in the moment). The necessity to include purpose in the definition of SWB is justified on the basis that certain activities yield low levels of pleasure (or positive affect), while still contributing to the person's well-being by yielding high levels of purpose, both on an experiential and an evaluative level (White & Dolan, 2009). Hence, the definition of SWB that we will use throughout this thesis includes the following four components: (1) life satisfaction; (2) positive affect; (3) negative affect; and (4) purpose, where we view purpose as being a distinct component of the cognitive dimension of SWB.

In accordance with Dolan and Kudrna's (2016) classification, we use happiness as a proxy for positive affect, anxiety for negative affect and worthwhileness[1] for purpose. Table 1 gives a brief overview of other frequently used terminologies associated with each of these, along with which type of measures they correspond to.

Dimension	Component	Frequently used terminologies	Type of measure
Affective	Positive affect	Happiness; pleasure	Experiential
	Negative affect	Anxiety	
Cognitive	Purpose	Worthwhileness; meaning	Experiential and/or evaluative
	Life satisfaction	Satisfaction	Evaluative

Table 1: Summary of the components of subjective well-being, including terminologies and type of measure.

While we are able to discern and isolate all essential components of SWB, linking these components together and designing unified measures to capture them remains a

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[1] We define worthwhileness as the sense that something significantly contributes to improving one's quality of life, in a way that is not necessarily affective. When asking about people's experiences of worthwhileness, the focus tends to be on how they feel about the activity that they are engaged in. In general, while a momentary sense of purpose might have an affective component to it, we consider it as a predominantly cognitive component of SWB, in that it is partly derived from people's pre-existing awareness of whether the activity that they are engaged in ought to be worthwhile, or purposeful. Nonetheless, we acknowledge that people most likely use some affective information to determine what level of purpose and worthwhileness they are feeling in the moment, given this pre-existing cognitive awareness of how purposeful an activity should be.

challenging task. Busseri and Sadava (2011) attempted this more explicitly, proposing five possible approaches to linking the components of SWB to each other. Specifically, they highlight the pros and cons of different ways of connecting life satisfaction, positive affect and negative affect to each other, but they conclude that it remains unclear whether SWB can reliably be captured as a single construct. It follows that the choice of well-being measure should also consider the distinction between the different components of SWB (Dolan & Kudrna, 2016).

Throughout this thesis, we consider well-being as being multi-layered and multi-dimensional. We treat each component of SWB as a distinct measure of well-being. In doing so, we recognise that they are highly correlated but separate constructs, as previous literature has shown as well (Diener & Emmons, 1984; Krueger & Schkade, 2008). While the upcoming chapters focus predominantly on experiential reports of well-being (happiness and worthwhileness in particular), we also consider evaluative measures of life satisfaction, happiness, anxiety and worthwhileness. Table 2 shows a breakdown of which measures are used in each chapter.

	Life satisfaction	Happiness	Anxiety	Worthwhileness
Chapter 3		X		X
Chapter 4		X		X
Chapter 5		X		X
Chapter 6	X	X	X	X

Table 2: Breakdown of well-being measures that are used in subsequent chapters of this thesis. Papers 1 to 3 focus on experienced measures only, while paper 4 incorporates evaluated measure also.

In the social science tradition, we rely on self-reported data, which raises the question of whether such reports of feelings can ever be truly "experienced". Indeed, one could argue that the very act of asking someone how they feel forces them to consciously make an evaluation about what they are feeling, regardless of this feeling pertaining to the moment itself or to the past. This, however, is only problematic if we expect people's momentary evaluation to be misaligned with their momentary experience. If this were the case, one may reasonably assume that this misalignment is incorporated in the experience itself. This cannot be said of when people are asked to recall how they feel *in general*, or in a past period, as the absence of the exact feeling at the time of reporting may cause misalignments between experience and evaluation that are driven by factors unrelated to the experience itself.

Typically, experiential measures ask people about how they are feeling *in the moment,* or in the very recent past (e.g., "yesterday"), while evaluative measures ask people to reflect on more extended periods of time (e.g., "all things considered", "in general"; Dolan & Kudrna, 2016; Kahneman & Krueger, 2006).

Notably, we do not discuss the normative approach to the study of well-being. Rather, the focus in the thesis is to gain a more complete understanding of the descriptive components of well-being and its psychological and behavioural determinants. We recognise thoughts as being part of the cognitive processes that are essential to the pursuit and attainment of well-being, as discussed in mental states theories. In the following sections, having defined SWB as an overarching construct, we provide a more comprehensive definition and overview of each of the four components of SWB, as described and used in the previous literature, including the measures that are traditionally employed to capture them.

Life satisfaction

In the early days of well-being studies in social sciences, the most common method used to look at people's well-being was to ask them to make an evaluation of how satisfied they were with various aspects of their life, using either single-question measures or multi-item questionnaires (Diener et al., 1985; Hills & Argyle, 2002). Single-item measures in broader well-being questionnaires use questions like "overall, how satisfied are you with your life nowadays?" (Dolan & Metcalfe, 2012).

Generally, measures of life satisfaction tend to be stable over time (Pavot & Diener, 1993, 2009), as the assessment of life satisfaction is based on salient information about the person's life rather than on their feelings (Diener, 1994). As such, measures of life satisfaction appear best suited to capture the impact of large circumstantial changes in people's lives. For instance, unemployment has been linked to lower life satisfaction, both between and within individuals (Gallie & Russell, 1998; Kassenboehmer & Haisken-DeNew, 2009; Luhmann et al., 2014). Other types of contextual factors, such as leisure (i.e., hobbies and exercise) or social capital (i.e., the value of an individual's social networks and connections), are strongly correlated with overall life satisfaction (Argyle, 1997; Elgar et al., 2011; Huang & Humphreys, 2012; Riddick, 1985), with some evidence suggesting a causal effect of exercising on life satisfaction (Dolan et al., 2014).

Personality typically accounts for more variation in life satisfaction compared to circumstances and contextual factors (Kahneman & Krueger, 2006; Richard & Diener, 2009).

For example, while there is little evidence for a lasting effect of marriage on life satisfaction in general, people with specific personality traits draw more lasting benefits from marriage than others (Boyce et al., 2016). In general, the personality traits that most strongly predict life satisfaction are neuroticism and extroversion (Diener & Lucas, 1999; Schimmack et al., 2002; Schimmack et al., 2004). Clark et al. (2018) further find that, while circumstantial factors like employment and income are important to individual life satisfaction, most of the between-person variation in life satisfaction is explained by mental health, which is closely linked to higher levels of neuroticism (Muris et al., 2005).

Positive and negative affect

The affective component of SWB have been captured both jointly and independently from one another. Early research suggested decomposing positive and negative affect into several facets (e.g., enthusiasm, excitement, distress, shame, etc.) and used a two-factor scale to capture them (see PANAS, Watson et al., 1988). For instance, Stone et al. (2006) use twelve different emotions (including happiness and worry) to capture positive and negative affect. In single-item measures, happiness is often used as a proxy for positive affect and anxiety as a proxy for negative affect, and many studies discuss these affective components of SWB separately. For positive affect, Dolan & Kudrna (2016) suggest using the question "how happy do you feel?". This is justified on the basis that people typically understand the word "happy" in a hedonic sense, and that it is therefore better suited to capture only the positive affect component of SWB rather than well-being as a whole. Similarly, they suggest using "how anxious did you feel?" for negative affect.

While positive and negative affect are strongly correlated, early research on genetic and environmental factors influencing affect showed that they are determined by different constructs. Specifically, negative affect depends more on individual-specific characteristics, while positive affect is better predicted by contextual factors and circumstances (Baker et al., 1992). Known predictors of positive affect or happiness include altruism (Dulin & Hill, 2003), social relationships (Sandstrom & Dunn, 2015), exercise (Zhang & Chen, 2019), mindfulness (Jislin-Goldberg et al., 2012), and exposure to nature (McMahan & Estes, 2015; Wang et al., 2019). Other contextual and environmental factors tend to have a more ambiguous effect on happiness. For example, time spent commuting negatively predicts the happiness of women, but not of men (Roberts et al., 2011), while it positively predicts happiness of teenagers on their way to school (Ruiz-Ariza et al., 2015).

The literature also finds strong relationships between personality traits and both positive and negative affect (Magee & Biesanz, 2018; Steel et al., 2008). Extraversion appears to be positively correlated with happiness (Argyle, 1997), while the opposite relationship is observed for neuroticism (Headey et al., 1985; Hayes & Joseph, 2003; Soto, 2015). Anglim and Grant (2016) find that all five dimensions of personality (i.e., agreeableness, conscientiousness, extroversion, neuroticism and openness) are significantly correlated with positive affect, although correlations for agreeableness and openness are smaller than for the other three traits. They further find that neuroticism, extroversion and conscientiousness were also the main predictors of negative affect (Anglim & Grant, 2016). To complement this, a large meta-analysis discussing anxiety-related disorders confirmed strong links between anxiety and high neuroticism and low extroversion, but also low conscientiousness (Kotov et al., 2010; see also, Gershuny & Sher, 1998).

Purpose

While we know that purpose is a distinct construct from life satisfaction, and positive and negative affect (Dolan, 2014; Dolan et al., 2017; Waterman, 1993), evidence tying it to the individual-specific characteristics and contextual factors that were discussed in relation to the other components of SWB is somewhat sparser. Instead, much of the research that focuses on purpose has been conducted in the context of another conceptualisation of well-being, namely, Ryff's (1989, 2014) multi-faceted account of psychological well-being. As a result, most of the literature takes an evaluative approach to the study of purpose (Huta & Waterman, 2014).

While Ryff's measure is a multi-item scale (see Ryff & Keyes, 1995), purpose measures used in the context of SWB typically consist of a single question asking individuals how worthwhile they perceive their life to be (Dolan & Kudrna, 2016; Dolan & Metcalfe, 2012). As an evaluative measure, Dolan and Metcalfe (2012) suggest using "overall, how worthwhile are the things that you do in your life?", while Dolan and Kudrna (2016) propose "how much purpose do you feel right now?" as an experiential measure.

Nonetheless, since Ryff's understanding of purpose closely matches the way we conceptualise it in the context of SWB – that is, as a measure of how meaningful or worthwhile people perceive their life to be – we discuss the evidence pertaining to both measures as relating to the same construct.

Determinants of purpose appear to be largely activity-specific and context-dependent (Dolan, 2014). For instance, work is one of the least pleasurable activities people engage in on a daily basis, but still plays an important role in how people assess their overall well-being. This can be explained by the fact that the lack of positive affect in work is compensated for by the purposeful nature of the activity (White & Dolan, 2009). Generally, activities such as working, volunteering, or spending time with kids appear to contribute more to the purpose dimension of SWB than the affective one, although these differences vary by gender. Furthermore, the company of other people makes most activities more purposeful (Dolan, 2014).

Conversely, individual-specific characteristics such as personality and self-esteem have been shown to predict purpose (Ryff, 2014). Specifically, early research links purpose to neuroticism, extroversion and conscientiousness (Schmutte & Ryff, 1997), which is similar to the trends we observe across the literature on the other components of SWB. Self-esteem levels – and the stability of these levels – also seem to predict purpose (Paradise & Kernis, 2002).

Synthesis of general determinants of SWB

The above-mentioned literature shows that contextual factors and individual-specific characteristics are strongly related to SWB, and that the main determinants of each component of SWB overlap. In terms of contextual factors, people's activities play an important role. Whether it is work, commuting, or leisure activities, it is clear that how people spend their time impacts their well-being (Dolan et al., 2008). In terms of individual-specific factors, the literature suggests that a large part of SWB can be traced back to personality or hereditary characteristics (Diener & Lucas, 1999; Lyubomirsky et al., 2005). In fact, personality appears to account for more variation in SWB than demographic information such as gender, income or age (Diener, 2009). Neuroticism and extroversion are the strongest predictors across all components of SWB (Costa & McCrae, 1980), and conscientiousness is a consistent predictor as well (Soto, 2015; Anglim & Grant, 2016).

This extensive evidence that both individual-specific characteristics and contextual factors act as determinants of SWB makes up the foundation of our proposed model. The present thesis builds on this evidence by studying how thoughts complement these relationships between contextual factors, individual-specific characteristics and well-being. In doing so, we expand on the existing research around the determinants of well-being by

exploring the direct relationship between thoughts and well-being, as well as how this relationship is moderated by individual-specific and contextual factors.

Thoughts

To understand how thoughts influence well-being and why they ought to occupy such a central place in well-being models, we must first define thoughts, both in the context of cognition and of their application in later chapters. The following sections treat of the definition of thoughts that will be used throughout this thesis and provide an overview of the relevant components of thoughts that we will study in relation to well-being.

Defining thoughts through cognition and consciousness

In 1967, Neisser defined cognition as follows: *"The term "cognition" refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used. It is concerned with these processes even when they operate in the absence of relevant stimulation, as in images and hallucinations. ... Given such a sweeping definition, it is apparent that cognition is involved in everything a human being might possibly do."*

In his definition, Neisser touches upon several important features that contribute to our current understanding of the human mind. First, it acknowledges a dynamic component that operates beyond the presence of physical stimuli and that allows us to assign different meanings to our experience of physical reality. Second, it establishes cognition as an overarching mechanism that governs both the conscious and unconscious determinants of our behaviour (De Houwer et al., 2018).

Where do thoughts fit into this definition? In relation to the first point, thoughts are directly imbedded in cognition, in that they are processes that contribute to meaning assignment on several levels (McMillan et al., 2013). Yet, thoughts are but a component of cognition, which is where the distinction between consciousness and unconsciousness becomes important. While some academic literature mentions "unconscious thoughts" (e.g., Singer, 2018), the association of those two words seems to be relatively rare in the field of psychology. When the term is used, it tends to refer to the unconscious processes that lead to the formulation of a conscious thought (Dijksterhuis & Strick, 2016). Instead, discussions around unconsciousness tend to focus on "the unconscious mind", or simply "the unconscious" (see Freudian literature, e.g., Mannoni, 2015). To think, then, ought to be a conscious activity. In the context of this thesis, where our ability to measure or capture thoughts in self-reports is essential, we shall treat it as such.

Taking into consideration the idea that our consciousness may not be fully dissociable from our feelings and emotions (Campbell, 1997), along with the previously stated definition of cognition, we can define thoughts as the conscious processes through which we give meaning to our external experiences (i.e., our physical and social reality), make sense of our internal experiences (i.e., feelings and emotions; see also Humphrey, 2018) and thereby influence our behaviour. In this manner, we can think of thoughts as an expression of consciousness. From this definition, it follows that thoughts are naturally related to well-being, both as a way to process well-being derived from external experiences and as internal experiences contributing to well-being.

Notably, there is an extensive clinical literature on thoughts and how they relate to mental health and well-being (e.g., intrusive thoughts, ruminations; Clark & Purdon, 1995; Harrington & Blankenship. 2002). However, in this thesis, we are interested in broader, non-clinical categorisations of thoughts. We therefore focus our review of the literature on research that is directly relevant to thoughts as they will be discussed in subsequent chapters.

Types of thoughts

Thoughts can be (and have been) categorized in many ways, both within and across disciplines (Andrews-Hanna et al., 2013; Baars, 2010; Schwartz, 1986; Smallwood & Schooler, 2006; Watkins, 2008). In the present thesis, the main distinction that we make is between thoughts that are related to the current activity that someone is engaged in (TCA) and thoughts that are in any way unrelated to what they are doing in that moment. Many terminologies have been used to describe such thoughts (e.g., self-generated thoughts, mind wandering, stimulus-independent thoughts or task-unrelated thoughts; Callard et al., 2013; Engert et al., 2014; Mason et al., 2007; Smallwood, 2013; Watkins, 2008). While these all refer to thoughts that share many characteristics, each definition comes with slightly different nuances. For instance, self-generated thoughts are thoughts that occur in the absence of external stimuli, while task-unrelated thoughts may include thoughts that arise due to external distractions (Barron et al., 2011; Unsworth & McMillan, 2014). As such, thoughts that fall under the same umbrella term of mind wandering can sometimes reflect very different internal experiences (see also, Wang et al., 2018). The context within which these thoughts are defined and the precise measures with which they are captured therefore matter, and recent research has stressed the importance of assigning the appropriate label to the thoughts that are studied (Irving & Glasser, 2020; Murray et al., 2020; Seli et al., 2015).

Seli and colleagues (2018) address this question of terminology by suggesting that all aforementioned types of thought could be regrouped under the umbrella-term of *mind wandering,* while acknowledging that the nuances proposed by each terminology are essential to capture the natural diversity and complexity of people's thoughts. They define mind wandering as "the conscious experiences that are not tied to ongoing events or to tasks that people are performing". Beyond this overarching definition, they also recognise the importance of adequately defining the specific thoughts that researchers consider in their studies, based on the hypotheses that they formulate and how they subsequently frame the questions they ask their participants (Seli et al., 2018). As such, we must ask ourselves the question of *what kind of mind wandering we are observing* before being able to discuss how we intend to build on the existing literature in the present thesis.

The term *task-unrelated thought* is frequently used in the experimental literature, referring simply to any thoughts that are not directed towards the experimental task that people are assigned (Allen et al., 2013; Smallwood et al., 2002; 2003a; 2003b). In this thesis, we understand the term *task-unrelated thought* to include thoughts that arise due to external distractions, as well as stimulus-independent thoughts. This definition is convenient as it captures the broadest possible range of mind wandering-like thoughts in a controlled environment (i.e., when the researchers themselves are able to set the task and monitor participants). Understanding what a task-unrelated thought actually refers to in an uncontrolled environment, however, is a little bit more ambiguous. Indeed, while these experimental tasks aim to mimic or reproduce real-life behaviours, they cannot account for the fact that day-to-day activities cannot always be clearly divided into tasks. People may, at any point, be attending to multiple things that they perceive as being tasks, or instead, be engaged in an activity that does not involve a task at all (Murray et al., 2020). In ecologically valid contexts, it is more complicated, then, to establish clearly what a "task"-unrelated thought is.

A clearer distinction might be made around the activity that people are engaged in. Indeed, while people may not always be engaged in a definite task, they are likely to be engaged in some form of activity, even if that activity is a passive one. The term *activity-unrelated thought*, however, has not been used in the literature to date. In the upcoming chapters of this thesis, we therefore use the label of task-unrelated thoughts (TUT) to discuss our findings in the context of the broader literature, but with the understanding that we are, in

fact, asking participants about whether their thoughts are related to the *activity* that they are engaged in as they go about their day-to-day lives, rather than asking them about tasks.

Using this as a starting point, the literature suggests that mind wandering accounts for nearly half of our experienced thoughts (Klinger & Cox, 1987; Killingsworth & Gilbert, 2010; Christoff et al., 2016). In general, higher occurrences of mind wandering are associated with easier tasks and less attention-demanding environments (Filler & Giambra, 1973; Christoff et al., 2016), or times when the brain is "at rest" (Mason et al., 2007; Christoff et al., 2009; Fox et al., 2015). It is also related to various aspects of performance (Baird et al., 2012; Randall et al., 2014; Risko et al., 2012; Thomson et al., 2014) and well-being (Killingsworth & Gilbert, 2010; Smallwood & Andrews-Hanna, 2013), whereby the occurrence of mind wandering tends to have a negative effect on both.

Determinants of mind wandering

People report different frequencies of mind wandering depending on their behaviour and the context in which we observe them. As such, Mason et al. (2007) argue that mind wandering become more frequent as people become more proficient at a certain task. This is attributed to the fact that proficiency decreases the amount of attentional resources that are required to complete the task, allowing more of those resources to be allocated to mind wandering. This does not prevent mind wandering from occurring in virtually any activity people report being engaged in (Killingsworth & Gilbert, 2010). Interestingly, the occurrence of mind wandering seems to be relatively stable on an individual level, where individuals that report higher proportions of mind wandering in the lab also report higher proportions in real life (McVay et al., 2009).

One major determinant of whether people report mind wandering or thoughts related to the current activity is the practice of mindfulness. Indeed, mindfulness has been systematically linked to lower proportions of mind wandering (Mrazek et al., 2012; Stawarczyk et al., 2012). These findings are not surprising considering that mindfulness promotes higher present-moment awareness (Sharf, 2015), which is by definition opposed to mind wandering.

Looking at individual-specific characteristics, studies on personality find significant associations between personality and mind wandering frequency (see Diaz et al., 2014; Glahn et al., 2010; Weiss et al., 2008). Specifically, neuroticism is systematically associated with higher proportions of mind wandering (Mason et al., 2013; Perkins et al., 2015) and openness

to experience seems to be related to mind wandering rates and content in day-to-day life (Kane et al., 2017). However, it appears that the effect of neuroticism is strongest in the lab and that openness was a significant predictor of both content and frequency of mind wandering only in real-life settings (Kane et al., 2017).

While the effects of individual-specific and contextual factors have been less studied in relation to thoughts, the aforementioned evidence suggests that there may be an overlap between determinants of thoughts and well-being. Upcoming chapters will explore this further by providing evidence of how contextual and individual-specific characteristics predict the occurrence of different types, as well as other components of thoughts, and how they moderate the relationship between these determinants and well-being.

Components of thoughts

The literature on thoughts recognises and measures various dimensions or components of thoughts (Andrews-Hanna et al., 2013). Besides type, these measures include *content*, *valence*, but also things like duration, intentionality or vividness (e.g., Mar et al., 2012; Seli et al., 2016; 2017). Most studies provide an account of one or two of these measures in relation to various individual-specific characteristics, internal experiences or behaviours.

Typically, studies take the frequency of reports of a specific *type* of thought as a starting point for their analysis (e.g., Brose et al., 2011; Mar et al., 2012). The *content* of a thought refers to what people report thinking about when reporting a TUT. This can be captured through an open-ended question or, more commonly, by providing respondents with a predetermined set of answers to choose from. Responses are then categorised according to various criteria, such as temporal (i.e., whether it is past- or future-related) or social (i.e., whether it self- or others-related) dimensions of the thought (e.g., Smallwood & O'Connor, 2011; Ruby et al., 2013; Nyklíček et al., 2021). While the actual content is not restrained to these categories, studies focus on these social and temporal dimensions because they are easy to quantify and tend to be applicable to many of the thoughts that people report. *Valence* refers to whether a thought is positive, neutral or negative (e.g., Poerio et al., 2013; Welz et al., 2018).

In the present thesis, we focus on these three components – type, content and valence of thoughts. However, as we categorise them, these components do not operate on the same level. While valence is measured for all types of thoughts, measures of content only provide

meaningful insights into TUT, as the content of TCA is determined by the activity that someone is engaged in. Table 3 shows how thoughts are categorised across these components.

	Valence		Type	Content		
Thought	Positive — OR — Neutral — OR — Negative		Related to the current activity OR	Related to the current activity		
			TUT	Social content	Self	
				Social content	Others	
				Temporal content	Past	
				Temporal content	Future	

Table 3: Visual breakdown of the components of thoughts relevant to this thesis, according to the level on which they interact with each other.

While many of these components have been studied in relation to well-being, few studies consider all of them simultaneously, and even fewer provide a comprehensive account of their effect on more than one well-being measure. The following part provides an account of the existing literature on the relationship between thoughts and well-being to inform the analysis that features in the upcoming chapters of this thesis and shed light on the effects we may expect from our analysis.

Thoughts and well-being

The debate surrounding the relationship between thoughts and well-being can be traced back to moral philosophers in the early 18th century (e.g., Locke, 1690; Hume, 1739). Since then, despite widely differing views and beliefs, philosophers have converged towards an understanding that the impact of thoughts on well-being is a complex, multi-layered matter that cannot be categorised as exclusively negative or positive (Sutton, 2010). In recent decades, this question has been widely adopted by social scientists. Specifically, the relationship between thoughts and well-being has been studied in the context of well-being enhancing interventions (Bryant et al., 2005; Wilkinson-Tough et al., 2010; Zenner et al., 2014) and there is an extensive body of evidence regarding the relationship between mind wandering and well-being.

Mind wandering and task-unrelated thoughts

While most of the literature adopts a balanced approach when describing the relationship between mind wandering and well-being, Killingsworth and Gilbert (2010)

suggest that mind wandering either has a neutral or a negative effect on well-being. They report that mind wandering has a systematically negative effect on happiness, and that it appears to cause low happiness rather than the other way around. This finding is echoed by Brose et al. (2011), who find that mind wandering is associated with higher reports of negative affect. Similarly, Mar et al. (2012) report a negative relationship between mind wandering and life satisfaction. As such, the early literature shows that mind wandering is negatively associated, either causally or correlationally, to three different components of SWB. While evidence on the relationship between mind wandering and purpose is lacking, other papers point towards the possible existence of a dynamic relationship between mind wandering and well-being. In particular, inducing negative moods in experimental settings has been shown to lead to an increase in TUT, both in terms of frequency and duration (Smallwood et al., 2009). More recent work has shown that the relationship between mind wandering and well-being also depends on the specific type of the mind wandering that participants are being asked about (Mills et al., 2021).

Potential mechanisms

While the social science literature does little to explain this negative relationship or what causes people to report one type of thought over the other, recent work has suggested a relationship between mind wandering, a state of reduced attention and lower well-being reports (Hobbiss et al., 2019). We also know from a vast body of evidence that attention is a limited resource (see Cavanagh & Alvarez, 2005; Kahneman, 1973, 2011; Randall et al., 2014, for different perspectives on this) and that the proper allocation of these attentional resources is all the more important as the activity becomes more attention-demanding (Randall et al., 2014). Our experience of a certain activity is therefore naturally related to the interplay between how much attention it requires and how much attention we actually pay to it. Taken together, these past findings may hint at an attentional mechanism that drives how we experience TUT (see Kane & McVay, 2012).

If we take thoughts to be an expression of what our attention is directed towards, then the distinction between TCA and TUT is really an indication of whether our attention is focused on external or internal stimuli. The question then becomes: which stimuli are more engaging or rewarding from a well-being standpoint? The literature on attention has recently shown that paying attention to external stimuli intensifies the emotional reaction that is associated with these stimuli (Mrkva et al., 2019; 2020). Following from this, it may be that

our mind naturally directs our attention towards the stimuli that are best – or least detrimental – for our well-being.

Specifically, if our experience of a certain activity has a positive impact on our well-being, it follows that we are probably better off thinking about our current activity. This is confirmed by research linking higher attentive involvement with higher enjoyment of an activity (Hamilton et al., 1984). Conversely, if the activity has a negative impact on our well-being, we may be better off reverting to TUT to avoid focusing too much on the activity itself (as shown in the context of curiosity-evoking distractions by Isikman et al., 2016). Therefore, if our brain frequently reverts to TUT, this may simply be an adaptive reaction to prevent TCA that would be related to comparatively worse well-being (Kane & McVay, 2012). In other words, TUT, and mind wandering in general, could function as an "experience dampener", whereby it would generally allow people to avoid the most negative well-being experiences. We label this the *experience dampener hypothesis.* Figure 2 provides an illustration of this mechanism.
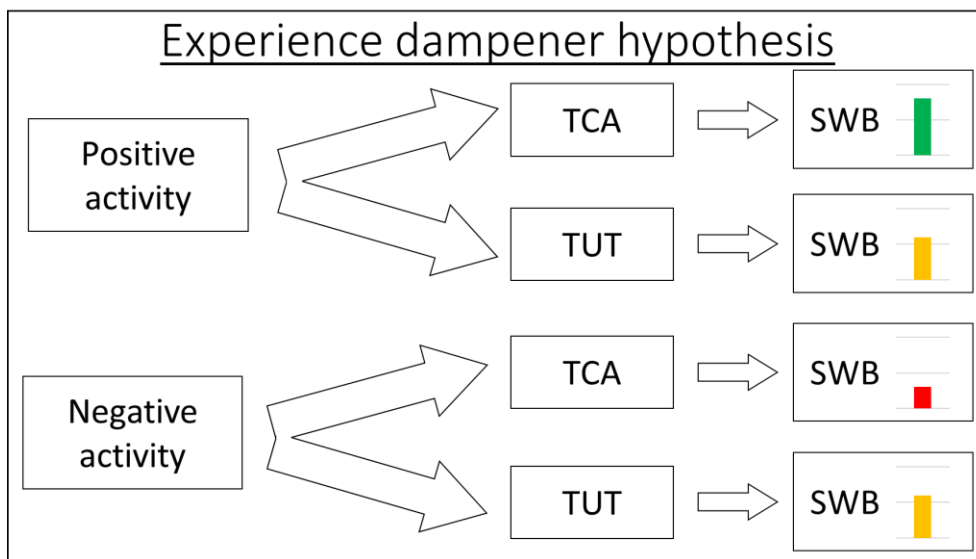
Figure 2: Graphical representation of the scenarios leading to the occurrence of mind wandering depending on how people perceive their activities. Note: arrows are unidirectional for simplicity, and merely aim to illustrate the relationships that are directly meaningful and relevant for the present hypothesis. We acknowledge that in reality, the relationship between activities and well-being is most likely bidirectional, and much more complex (i.e., influenced by other unobserved variables) than illustrated here.

The experience dampener hypothesis complements Smallwood and Andrews-Hanna's (2013) context-regulation hypothesis, which stipulates that the experience of mind wandering is dependent on the context in which it arises. They argue that mind wandering is more

prevalent in low attention-demanding activities, and that people derive more benefits from mind wandering in such contexts. In this sense, the context-regulation hypothesis also suggests an adaptive quality to mind wandering.

However, this is not to say that mind wandering is *always* adaptive. Indeed, TUT may also result from a failure to allocate the necessary attentional resources to a given activity (Kane & McVay, 2012; Killeen, 2013; Randall et al., 2014). In other words, we know that sometimes, our mind wanders *despite* our (or its) best efforts. This may happen, for instance, when we want to focus our attention on an activity that would typically be beneficial for our well-being, but we fail to do so because we are too tired, or some other, stronger stimuli divert our attention to something less pleasant (see also, Thomson et al., 2015). In such cases, the very occurrence of this failure may cause a reduction in well-being in and of itself, as illustrated in figure 3.
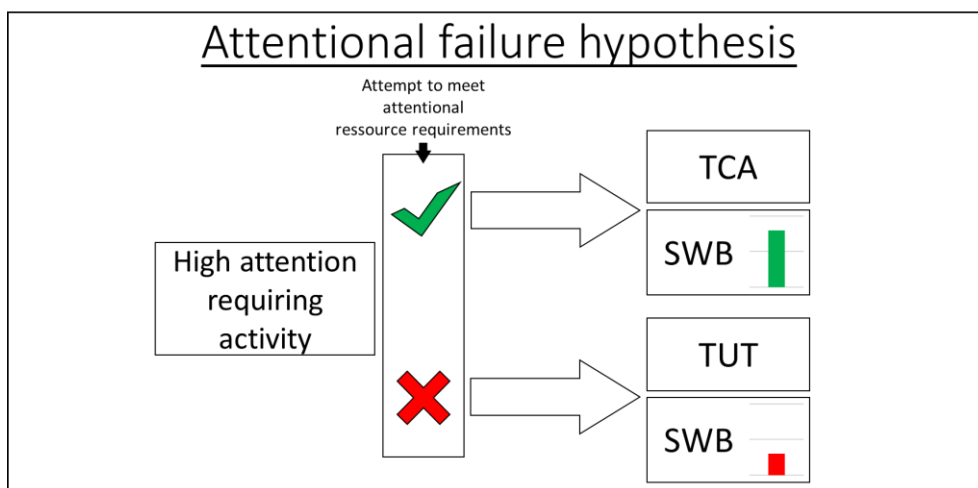
Figure 3: Graphical representation of the scenario leading to the occurrence of mind wandering depending on whether people manage to meet the attentional requirements of said activity. Note: arrows are unidirectional for simplicity, and merely aim to illustrate the relationships that are directly meaningful and relevant for the present hypothesis. We acknowledge that in reality, the relationship between activities and well-being is most likely bidirectional, and much more complex (i.e., influenced by other unobserved variables) than illustrated here.

According to this *attentional failure hypothesis*, it seems fairly intuitive, then, that while TUT may not lead to worse well-being than TCA *per se*, the attentional mechanisms that cause people to report TUT would naturally lead them to be associated with lower well-being reports. This idea is further supported by evidence showing that higher frequencies of mind wandering tend to be associated with a reduction in both cognitive resources and

processing of perceptual information (Stawarczyk et al., 2012), both of which would likely be associated with a failure to allocate necessary attentional resources.

Taken together, the above-mentioned mechanisms would explain why TUT and mind wandering in general are associated with lower levels of well-being, despite the fact that they might not actually cause these lower levels of well-being. In the upcoming chapters, we challenge this idea that mind wandering has a systematically negative effect on well-being, while further exploring the possibility that it could function as a "dampener" of well-being, as suggested by *experience dampener hypothesis*. Even though the data that are discussed in the later chapters of this thesis do not allow us to definitively confirm the validity of these mechanisms, we present evidence that is aligned with the predictions that can be derived from them. That being said, to focus solely on types of thoughts would be overlooking the inherent complexity of TUT and their other components.

Valence of thoughts

In discussing mind wandering, the literature often makes the distinction between positive, neutral and negative mind wandering. For example, Killingsworth and Gilbert (2010) find that neutral and negative mind wandering is associated with lower reported happiness relative to reports of TCA, while positive mind wandering is not associated with significantly higher happiness than TCA. This conclusion, however, has been challenged by most of the literature since. While researchers agree that negative mind wandering tends to be associated with lower well-being both in experience sampling studies (Brose et al., 2011; Kircanski et al., 2018; Poerio et al., 2013) and in experimental settings (Marchetti et al., 2012; Smallwood & Andrews-Hanna, 2013), there is also a large body of evidence supporting the claim that positive mind wandering is associated with higher well-being (Franklin et al., 2013; Schooler et al., 2014; Welz et al., 2018). One study also finds a positive correlation between positive mind wandering and higher purpose in life (Blouin-Hudon & Zelenski, 2016).

Unfortunately, most of these studies focus on experimental data, and the few studies using experience sampling often fail to compare valence of mind wandering and valence of TCA. Specifically, the current literature overlooks the fact that valence of thought may be an important driver of well-being regardless of the type of thought. Instead, researchers have mainly focused on comparing mind wandering of different valence to aggregated TCA (e.g., Killingsworth & Gilbert, 2010). In the present thesis, we consider valence of thoughts as an

overarching construct that is common to all types of thoughts, rather than one that is specific to TUT. As such, it is plausible that valence of thoughts in general predicts well-being, but also that the valence of TUT is associated to well-being differently compared to the valence of TCA, and upcoming chapters will explore this.

Content of TUT

Smallwood and Andrews-Hanna's (2013) *content-regulation hypothesis* states that the content of mind wandering is susceptible to influence mood states and well-being (Smallwood & Schooler, 2015). It also acknowledges that content is highly variable, stressing the importance of studying the content of people's thoughts (Andrews-Hanna et al., 2013; Welz et al., 2018). Other research has also emphasised the potentially adaptive qualities of specific contents of thoughts (e.g., social daydreaming; Poerio & Smallwood, 2016). However, research on content of thoughts has traditionally been limited by the specificity of self-reports and the resulting classifications.

In general, literature that looks at the content of a thought focuses predominantly on the socio-temporal dimensions of this content (i.e., who the thought is about, and whether it is related to the past or the future). In experimental settings, past-related thoughts seem to be negatively associated with mood, while the opposite is observed for future-related thoughts (Smallwood & O'Connor, 2011; Ruby et al., 2013). Furthermore, thoughts that are both future and self-oriented are associated with positive moods (Oettingen, 2012). There is also evidence that thinking about others has a positive impact on well-being (Poerio et al., 2015; 2016). A recent experience sampling study that explored the effect of content of thoughts on well-being also explicitly asked participants to self-report the social and the temporal orientation of their thoughts, and found very similar results to those mentioned above (Nyklíček et al., 2021). Indeed, they report significant positive relationships between happiness and future- and others-related thoughts, and a negative relationship between happiness and past-related thoughts. They found no significant evidence of a relationship with self-related thoughts.

Although content of thought is typically understood to precede mood, Poerio et al. (2013) find evidence that different moods can also influence the content of people's thoughts. It appears that inducing sadness and negative moods causes people to report more mind wandering about current and past concerns. Different strands of research support this idea, as happy vs sad moods had different effects of a range of thought-related processes (e.g.,

memory, group vs individual focus, etc.; Clore & Huntsinger, 2007). This points towards the existence of a dynamic relationship between content of thoughts and well-being, although Nyklíček and colleagues (2021) did not find any long-lasting effects of content of thoughts on future well-being. Generally, more research using experience sampling in real-world settings needs to be conducted to better understand the extent to which content of mind wandering relates to well-being.

The upcoming chapters of this thesis make a step in this direction by considering the social and temporal dimensions of content of TUT in an experience sampling context and discussing their effect on well-being alongside the effects of valence and type of thoughts. We use these two dimensions of content for their generalisability across thoughts, and because they enable us to use previous work as a basis to compare our findings to.

Synthesis of thought and well-being review

While all the components of thoughts that will be considered in this thesis have been studied previously, methods and context of these studies widely vary. Much of the literature focuses on correlational evidence or uses experimental settings to study just one or a couple of components of thoughts in isolation. As a result, questions regarding how all these components interact in real-world settings remain unanswered.

Furthermore, research that is conducted both in the lab and in the real world warns against the generalisability of experimental findings relating to thoughts (Linz et al., 2019). Even studies that find causal effects fail to consider several components of thoughts, resulting in conclusions that lack nuance or that paint an inaccurate picture of how thoughts affect well-being. It is not surprising, then, that thoughts have not been incorporated into broader models that attempt to explain variance in well-being. This thesis aims to rectify this by using the previously discussed literature as a theoretical and methodological basis, and by bringing together all aforementioned components of thought and well-being (specifically, positive affect and purpose) using multi-level modelling (as seen in Brose et al., 2011; Killingsworth & Gilbert, 2010; Nyklíček et al., 2021) on a large experience sampling dataset.

Practical applications of the study of thoughts and well-being

While the main aim to this thesis is to explore in more depth how thoughts and their different components may be incorporated into broader models predicting well-being, the ultimate end of this research is to better understand internal processes in order to apply this knowledge to the design of more effective well-being enhancing interventions. Our use of

experience sampling through mobile technologies to collect the data that will be used in upcoming chapters provides us with a unique opportunity to test such an intervention alongside our data collection.

Indeed, if asking our participants to repeatedly report on their thoughts and their well-being can help us better understand how these two constructs relate to each other, it may also draw the participant's attention to some aspects of this relationship, or to the context in which they experience certain thoughts and feelings more generally. In chapter 6, we argue that this may have functioned as a well-being enhancing intervention.

With the field of well-being enhancing interventions using mobile technologies becoming increasingly popular among clinical and social scientists, we briefly discuss the related literature, and the possible role of thoughts in such interventions, in the subsections below.

Use of mobile apps

Recent years have seen a rapid rise in the number of self-help apps that focus on mental health (McKay et al., 2019). With mobile technologies becoming increasingly widespread and versatile, practitioners as well as private companies have been able to incorporate more and more complex forms of psychological and behavioural interventions, such as cognitive behavioural therapy (CBT; Rathbone et al., 2017), meditation training (Walsh et al., 2019) and other elements of positive psychology (Marshal et al., 2020) in these easy-to-access tools. However, one major issue that has been highlighted in systematic reviews of these app is their general lack of evidence-based frameworks (Martinengo et al., 2021; Miralles & Granell, 2019).

Indeed, while research suggests that these apps are associated with small to moderate improvements in various metrics of mental health and well-being (Bostock et al., 2019; Gal et al., 2021; Spijkerman et al., 2016), there appears to be a disconnect between app developers and the scientific community (Howells et al., 2016; Miralles & Granell, 2019; Van Ameringen et al., 2017). While many of the tools that are being developed are based on existing techniques and interventions that have previously been administered through in-person contact, it is unclear how users react to the digital versions of these interventions.

Although the consensus in the literature is that more robust research is needed to assess the immediate and longer-term effects of mental health apps, some progress has been made in establishing what works. For instance, the literature suggests that the inclusion of

behavioural change interventions, perceived trustworthiness and user-centred design are important predictors of engagement with the app (Szinay et al., 2020; Torous et al., 2018), and that an important limiting factor of most of these apps is the lack of personalised or personalisable interventions (Stawarz et al., 2019; Woodward et al., 2020). Qualitative explorations of how participants in online intervention studies respond to these interventions suggest that people's acceptance of these apps depends both on their perception of the specific techniques used in the apps and on their general openness to digital self-help tools (Walsh et al., 2018).

It appears that what matters most for people's well-being is not necessarily which type of interventions they are presented with, but rather how many they complete within the app, particularly when usage of the app is voluntary (Parks et al., 2012). It is still unclear whether – or which – specific techniques are more or less effective in improving mental health (Firth et al., 2017).

User-friendliness, alongside ability for users to track their progress and self-monitor, appear to be other indicators of effectiveness (Chandrashekar, 2018). In addition, behaviour change apps tend to perform better when they involve researchers and experts at the design stage (Fitzgerald & McClelland, 2017), stressing the importance apps using robust empirical frameworks.

Working with thoughts

In the context of mental health interventions, working with thoughts – in particular, thought journaling – is an integral part of CBT (Kazantzis et al., 2018), and has been applied in mobile apps previously. Moberg and colleagues (2019) showed that participants who filled in more unprompted thought records in their app showed lower levels of depression and higher levels of self-efficacy than those who filled in less. Other thought diary interventions that focus on making people highlight positive thoughts, such as gratitude, also find lasting positive effects on various indicators of psychological well-being and mental health (e.g., Southwell & Gould, 2017).

In academia, thought diaries have been used predominantly as a data collection methodology to help better understand how people's thoughts relate to how they feel (e.g., Brosschot & Van Der Doef, 2006; Ford et al., 2018). Yet, there is also some evidence to suggest that the mere practice of repeatedly reporting one's thoughts and/or well-being using

measurement tools like Ecological Momentary Assessment (EMA) may be beneficial to people's well-being in and of itself (Beames et al., 2021; Kramer et al., 2014).

As the data that we use to explore the relationship between thoughts and well-being was collected as part of a set of broader studies that involved several randomised controlled trials using EMA and Day Reconstruction Method (DRM) questionnaires that all asked people to report both their thoughts and their well-being, we make use of this broader data to establish whether reflecting on one's thoughts and well-being can improve well-being too. In doing so, we highlight the importance of understanding how awareness of thoughts and well-being can contribute to the design of simple and effective well-being enhancing tools.

Main aims

In this introductory chapter, we laid out the theoretical foundations of the well-being model that we study in the following chapters. This model highlights individual-specific characteristics, contextual factors and thoughts as major determinants of well-being. Namely, we argue that thoughts are an understudied determinant of well-being and that their components ought to be considered as core predictors of well-being, including purpose, which has not been incorporated in most well-being models until now. In addition, we suggest that the data collection tools that we use in the upcoming chapters may work as well-being enhancing interventions through the way they allow participants to reflect on their thoughts and well-being. As such, the aims of the present thesis, as stated in the introduction, are:

(1) *to explore the association between different components of thoughts and well-being.* This is done in chapter 3 by applying fixed-effect models to an experience-sampling panel dataset using thought components and interactions between them to explain within-person variations in *experienced* positive affect (happiness) and purpose (worthwhileness). The panel structure of the data will allow us to get closer than previous studies to estimating a causal relationship between thought components and well-being, by accounting for time-invariant unobserved heterogeneity at the individual level;

(2) *to understand how individual-specific characteristics and context affect the relationship between thoughts and well-being.* This is done in chapters 4 and 5. In chapter 4, we apply multi-level modelling using random slopes to test whether the relationship between thoughts and well-being differs from person to person. We

also include interactions between components of thoughts and Big 5 personality traits to see whether there is evidence of personality traits moderating the relationship between thoughts and well-being. In chapter 5, we look at whether the relationship between thoughts and well-being differs depending on contextual variables (i.e., what they are doing and who they are with). In these chapters, we also test whether the occurrence of different components of thoughts is predicted by these individual-specific and contextual variables;

(3) *to provide an overarching framework that clearly outlines the relationships between thoughts, well-being and its other known determinants, to serve as a reference point for future research in the field.* In addressing the two previous aims, and bringing together the findings from chapter 3 to 5, we provide empirical evidence for the overarching model we propose in this first chapter. This model brings together claims made in previous work and leans on existing theories (e.g., context- and content-regulation hypotheses, Smallwood & Andrews-Hanna, 2013) to clarify the role of thoughts as a determinant of well-being;

(4) *to assess whether the act of repeatedly reporting thoughts and well-being for data collection purposes can also be used as a well-being enhancing intervention.* We do this in chapter 6, by using well-being reports before and after three RCTs that asked people to report their thoughts and well-being using EMA and DRM. We test whether repeatedly reporting thoughts and well-being over the course of two to three weeks resulted in improvements in well-being and mental health measures.

In the process of addressing these aims, we fill several gaps in the current literature, namely by providing the first account of how type, valence and content of thoughts affect well-being *simultaneously* rather than in isolation. Furthermore, we relate these to the purpose component of well-being, something which no paper has done to date. We also establish or clarify the causal direction of the relationship between several components of thoughts and well-being. Finally, we suggest that the act of reflecting on thoughts and well-being for the purpose of data collection may have positive externalities on people's well-being, highlighting the importance of continuing to explore the relationship between thoughts and well-being, and how it may be applied in more widespread well-being enhancing interventions.

Chapter 2: Data

While much of the literature on thoughts focuses on experimental data, experience sampling (also known as ecological momentary assessment, EMA) has been recognised as the most appropriate method to capture thoughts and well-being in ecologically valid settings, while also allowing for causal inference (Smallwood & Schooler, 2015). To address the aims presented in chapter 1, we therefore use data collected in a large-scale study using EMA questionnaires in chapters 3 to 5. In chapter 6, we use data from two studies combining EMA and Day Reconstruction Method (DRM; see Diener & Tay, 2014; Kahneman et al., 2004), and one study using DRM only. In the following sections, we first discuss the literature on EMA. We then outline the main measures that will be used in the upcoming chapters, as well as some dataset characteristics.

Ecological Momentary Assessment

EMA were first used in clinical psychology to better understand the real-time behaviour and feelings of people struggling with addictions like smoking and alcoholism (Rouse & Biddle, 2010; Shiffman et al., 1997; Shiffman, 2005). The method consists of asking people to report their current activity and to answer a range of questions regarding how they are feeling and what they are thinking about in the moment (Stones et al., 1999).

EMA vary in their design depending on the objectives of the study, but Shiffman et al. (2008) identify a handful of characteristics that are inherent to them: (1) data collection takes place in a real-life environment, which provides ecological validity; (2) all questions and reports are based on the subject's current activity and state, to avoid retrospective biases; (3) moments are selected strategically depending on the needs of the study; and (4) subjects are asked to complete several surveys over the course of the assessment.

EMA's main distinctive feature is its ability to avoid retrospective biases without taking subjects out of their real-life environment. Although some studies find that there are little differences between the retrospective reports and momentary ones (Shrier et al., 2005), others find significant differences, namely in the reported intensity and frequency of feelings and activities (Van den Brink et al., 2001). Miron-Shatz et al. (2009) talk about a memory-experience gap, where people seem to assign stronger emotions to their day when assessing it retrospectively, implying that the same experience may be assessed differently depending on when or how people report it.

One of the downsides of methods such as EMA is that they are difficult to apply to large population samples because of the complexity and intrusiveness of reporting (Dolan & Metcalfe, 2012). However, modern technology is dampening these constraints through the widespread use of smartphones in daily life.

Other limitations to the use of EMA include the potential presence of reactive bias and selection effects. Reactive bias may occur when reporting thoughts or well-being, as explicit attention is drawn to internal processes that people may have been experiencing without really attending to them, thus interrupting the natural experience and potentially changing the way it is perceived by the sole means of asking about it. While it is difficult to rule out the presence of reactive bias completely, this phenomenon is not exclusively negative, as it also allows for the reporting of those thoughts and feelings that may otherwise have been lost in evaluative measures.

As far as selection effects are concerned, they may arise on two levels: (1) by process of attrition, with participants dropping out of the study in a non-random manner; and (2) by participants failing to answer some of the EMA prompts in a non-random manner. However, these concerns can be addressed on a statistical level, (1) by comparing the samples of participants that dropped out to those that stayed in the study for systematic differences; and (2) by checking for non-random answering patterns both within participants and across the entire sample. Additional selection bias may arise at the level of people choosing to participate in the study in a non-random manner, although this is not an issue that is encountered exclusively in EMA studies.

In the final chapter of this thesis, we look at how the use of EMA may be associated with positive externalities in terms of improving well-being or mental health reports of participants. Although we do not analyse the data that participants report through these data collection methods directly, the studies reported in that chapter assess the effects of filling in EMA and DRM questionnaires.

The DRM is a data collection format that closely resembles the EMA, in that it asks people to report a range of feelings alongside what they were doing and who they were with at different points during the day (Diener & Tay, 2014). The main difference is that, rather than asking people to fill in a short questionnaire about what they are doing and how they are feeling at random moments during the day, the DRM asks people to retrospectively recall their previous day, as if they were writing a diary (Kahneman et al., 2004). Comparing EMA

to DRM, research suggests that both methods provide similar assessments of feelings like happiness, stress or frustration (Grube et al., 2008; Dockray et al., 2010), which is why we look at them jointly in terms of assessing whether they might be function as well-being enhancing interventions.

Data collection

In chapters 3 to 5, we use data collected in January and February 2019 using the Reflections app, which was designed in partnership with Koa Health (then, Telefonica Alpha). The app sent participants six notifications a day, one with a DRM questionnaire, and five with EMA questionnaires to fill in. EMA questionnaires were sent at random times in separate two and a half hour chunks of the day, to make sure that participants received questionnaires all throughout the waking day. They had 30 minutes to open the notification once it appeared on their phone, after which the questionnaire expired. This was done to make sure that participants were actually answering the questions in the moment of experience, rather than simply when they happened to check their phones after the experience. The following sections discuss the measures of well-being, thoughts and context that were used in all three chapters.

On top of this, participants filled in an onboarding questionnaire including a personality questionnaire and measures of overall well-being, and an exit questionnaire capturing these same well-being measures. The overall well-being measures were used in chapter 6, alongside similar ones from two additional longitudinal studies involving the Reflections app and another app of the same type. More details on these overall measures are presented in the Methods section of chapter 6. The full onboarding, exit, EMA and DRM questionnaires can be found in Appendix A1.

Well-being measures

Based on the literature discussed in chapter 1, we use two experiential measures of well-being in the EMA questionnaires, to capture experienced positive affect and purpose. Participants are asked the following two questions, in relation to the activity that they were engaged in at the time of notification:

1. *How happy did you feel?*

2. *How worthwhile did this feel?*

Both questions were answered on a scale of 0 (Not at all) to 10 (Completely), and were asked in every single questionnaire, thus enabling us to keep track of fluctuations in happiness and worthwhileness levels throughout the study. These well-being questions were asked after participants had answered all other questions, as outlined below.

The study focused specifically on experiences of positive affect and purpose as these were the main measures used in previous work by the principal investigator of the broader study (Dolan, 2014; White & Dolan, 2009). Specifically, these measures are used to allow for an easy comparison of how experiences of hedonic and eudemonic well-being change depending on the individual and on the context. We particularly care about whether these two constructs do in fact capture different facets of experienced well-being, as previous research has mostly focused on comparing evaluative accounts of these measures, concluding that they are overlapping but distinct constructs (Disabato et al., 2016; Huta & Ryan, 2010; Ryan & Deci, 2001).

Contextual questions

Every EMA questionnaire started in the same manner, by asking participants to report what they were doing. All participants had to answer the following question: *"What were you doing just now?"*, using one of 18 predefined activities, or by adding another activity in an open text box. These activities were later recoded to match the broader categories of activities that were used in Killingsworth and Gilbert's (2010) paper on the relationship between mind wandering and happiness. We distinguished between 24 different activities, 22 of which belonged to the original list in Killingsworth and Gilbert's (2010) paper. The two activities that were added were "studying", to account for the fact that data was collected among LSE staff and students, and "social media", to account for the fact that this has become one of the major things that people spend time on over the past decade. Following the activity question, people were asked to report how long they had been engaged in the activity for.

Next, participants were asked to report who they were with by completing the following statement: *"I was with:"*, using one of 7 predefined types of company, or by adding another type of company using an open text box. These types of company were then recoded into the six most recurring categories. No previous paper was used as a basis for this classification, as no study investigating the relationship between thoughts and well-being has previously looked at how this relationship varies depending on the company that people report.

Participants were also asked to report where they were using the following question: *"Where were you?"* However, as this question showed very little variation in answers (almost all answers were either "at home", "at work" or "at university"), and these answers were not deemed to add much value compared to the reporting of activities, we elected not to investigate location as an additional contextual variable in the upcoming chapters.

Thought measures

Following these contextual measures, participants were presented with the following statement: *'I was thinking about:'*, and a list of predefined options, as well as the possibility to simply describe their thoughts themselves. The first option they saw was always "the current activity", while all other available options implied thoughts that were in some capacity unrelated to the participant's current activity. As such, by answering this prompt, participants provided information on both whether they had experienced TUT, and on the specific content of these TUT. Valence of thoughts was asked in a subsequent statement *'This thought was:'*, where participants could choose between one of three options (i.e., "positive", "neutral" or "negative"). Each thought could have only one valence, but participants had the possibility to report more than one thought if they felt this was appropriate.

While most content options that participants were given were fairly general (e.g., "friends", "events from the past", "about my future"), all answers were recoded before analysis into broader categories of social and temporal dimensions. As such, upcoming chapters will consider thoughts that were related to others or to the self along the social dimension, and thoughts that were related to the past or to the future along the temporal dimension. Not all thoughts had a clear social or temporal dimension to them. When these dimensions were unclear, or absent from the report, the thought was classified as having no explicit social and/or temporal orientation.

For example, the thought "friends" was categorised as having a social dimension (i.e., the thought was about other people), but no specified temporal dimension. Similarly, "events from the past" was categorised as having a temporal dimension (i.e., the thought was about the past), but no specified social dimension. The thought "about my future" was categorised as having both a social (i.e., the thought was about the self) and a temporal dimension (i.e., the thought was about the future). It was also possible for thoughts to have neither a specified social nor temporal dimension (e.g., thoughts like "food", "politics", "weather" were too generic to be assigned specific social or temporal dimensions). The coding of thoughts was

done by the author of this thesis. It was then checked and approved independently by the co-authors of the papers presented in chapters 3 and 4.

EMA questionnaire

In the final version of the EMA questionnaires, the questions were ordered as shown in figure 4 below. Participants were asked about their activity first. They could select as many activities as they deemed relevant, as most activities were not mutually exclusive. For example, someone could plausibly be "resting" and "watching TV", or "commuting", "reading" and "listening to music" at the same time. Next, they were asked who they were with. Once again, since the type of company was not mutually exclusive (e.g., people could be both with "family and "friends" at the same time), they were allowed to report as many types of company as they deemed relevant.
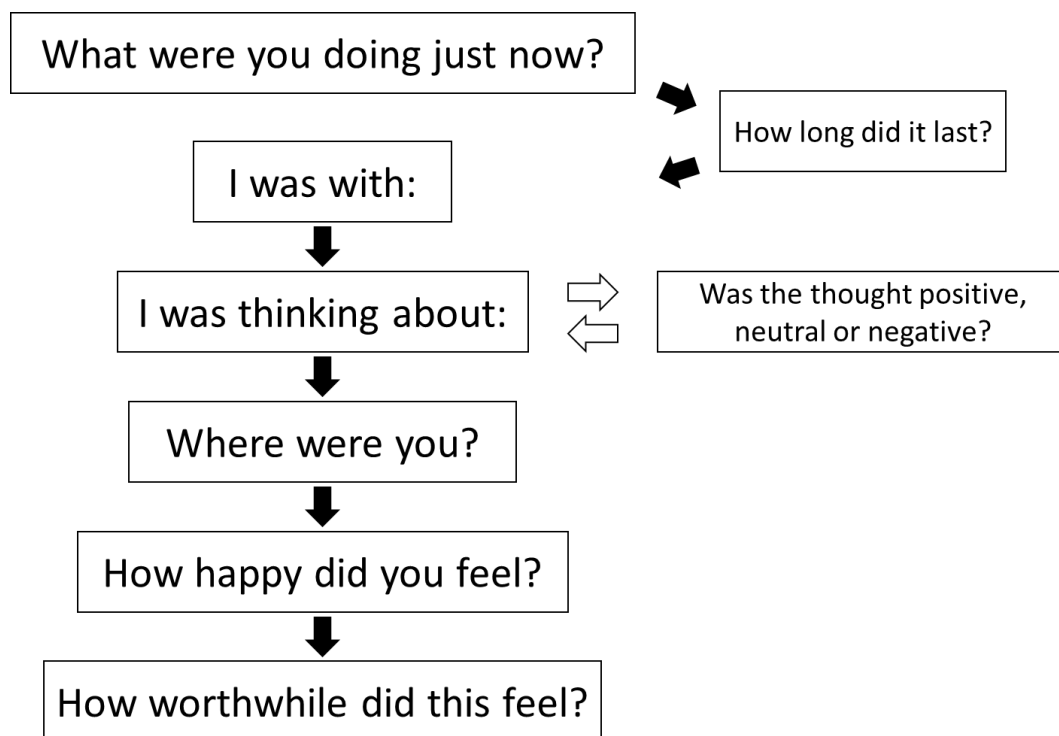
Figure 4: Order of questions in all EMA questionnaires, as seen by participants.

Next, they were asked to report what they were thinking about. Just like with activities and company, we decided to allow people to report however many thoughts they deemed relevant, despite the fact that most of the literature takes a different approach. In previous research, participants tended to be asked questions about their thoughts that involved mutually exclusive options (e.g., whether they were mind wandering or not; Choi et al., 2017; Killingsworth & Gilbert, 2010). Intuitively, this does not seem entirely plausible.

For instance, when someone is cooking, they may be thinking about their current activity, which is preparing food, while also letting their mind wander to a conversation they had with a colleague earlier that day. Or, while commuting, they may be paying attention to which stop they need to get out at, while also thinking about their holiday plans. In situations like this, their attention may be split between a TCA and a TUT. It seems equally plausible that people that might have several TUT simultaneously. For instance, recalling a great party, while thinking about how fun your friends are, might constitute two separate TUT, as one focuses on an event in the past, while the other on a character trait of your friends. Implications of this design choice are discussed in more depth in the discussion of chapter 3.

After each thought that people report, they indicate whether that thought is positive, neutral or negative, before being redirected to the thought prompt in case they want to add another thought. Finally, they report where they are, and then their happiness and their worthwhileness.

We note that while "this" in the worthwhileness question was intended to refer to the activity that people were engaged in, for comparability with previous studies (see Choi et al., 2017; White & Dolan, 2009), the order in which the questions were presented may have caused participants to report their feelings of worthwhileness relating to other aspects of the EMA questionnaire, such as their thoughts, as these were reported after people's activity. In the context of the present study, this is not necessarily problematic, as we are interested in both activities and thoughts, and how these relate to well-being. Additional notes on the study design and screenshots of how the questions were presented in the app are available in Appendix A6.

In addition to EMA questionnaires, our participants filled in one DRM questionnaire every day. Specifically, they are asked to provide a full breakdown of their day by listing the specific time frame of each of their activities, until they fill the entire day, and they are asked to report how they felt during each of these time frames. In our study, participants were asked to provide the same information as in the EMA questionnaires, meaning that they also provide a retrospective account of their thoughts, which is not typically part of DRM questionnaires. This DRM questionnaire was sent to participants every morning before they received the notification for the first EMA questionnaire of the day. In the context of the present thesis, only the effects of filling in DRM questionnaires (alongside EMA or as a stand-alone intervention) are discussed.

Dataset characteristics

Large panel datasets with many waves are prone to various issues relating to missing data. In the present study, participants were asked to fill in a maximum of 70 EMA questionnaires, 14 DRM questionnaires, one onboarding and one exit questionnaire. It is unlikely that participants would have been able to answer every single one of these. Since this presents a potential limitation for all upcoming studies, we address concerns of missing data here.

Focusing specifically on the EMA data that are used in chapters 3 to 5, the final dataset deals with missing data on two levels: (1) participant attrition, as participants may have dropped out all throughout the study, sometimes without meeting the inclusion criteria in upcoming chapters; and (2) missing observations within participants, where the majority of participants that are included in our sample failed to complete every single EMA that was sent to them. Before turning to our analysis, we address concerns that data were missing in a non-random manner on both levels.

Participant attrition

We address the concern of non-random participant attrition by comparing demographics, individual-specific characteristics and global well-being levels reported in the onboarding questionnaire of participants that were included in the analysis of chapters 3 and 5 (N=531; chapter 4 used a slightly adjusted sub-sample, as it required participants to have completed a full personality questionnaire on top of the EMA inclusion criteria that were used in other chapters) and participants that were not (N=285). We find no significant differences in gender, student status or nationality across samples. Similarly, participants that dropped out did not report significantly different personality traits, levels of optimism or self-esteem than those included in the final sample (all p-values > 0.05).

We find no significant differences in reports of evaluative measures of happiness (positive affect), worthwhileness (purpose) or life satisfaction between the two samples, but participants that dropped out after the onboarding survey did report significantly higher levels of anxiety (negative affect), both "in general" (p < 0.01) and "yesterday" (p < 0.01). It is unclear why this difference was found. It could be that more anxious participants felt that the study would be too stressful or otherwise anxiety-inducing after the onboarding. This may have been induced by the large number of individual-specific characteristics questionnaires

that people had to answer before the study. Perhaps having to reflect on certain personality traits exacerbated the anxiety of participants who tended to be more anxious to begin with.

Finally, participants that dropped out before meeting the final sample inclusion criteria reported belonging to slightly older age groups ($p < 0.05$). We attribute this to the possibility that the monetary incentive for continued participation may have been relatively less meaningful to older people, who would have been more likely to have a full-time job or savings to live off of.

We further note that when accounting for multiple hypotheses testing, with either a Bonferroni correction or a False Discovery Rate Controlling Procedure, we find no significant differences between the final sample and the sample of people that were excluded from the study, either in terms of demographics or starting levels of well-being. On the basis of this, we conclude that, while we cannot claim definitively that data are not *missing completely at random* (Heitjan & Basu, 1996; Kristman et al., 2005), there are little observable differences between the two samples.

Within-sample attrition and missing data

We further check whether there was a relationship between the mean happiness and worthwhileness reports and the number of days participants remained in the study, to account for differences between people who stayed in the study until the exit questionnaire and people who dropped out of the study along the way. We find no significant effect of the number of days that participants stay in the study (i.e., the amount of days between their onboarding completion and their last EMA entry) on mean reported happiness ($p = 0.19$) or worthwhileness ($p = 0.71$). From this, we conclude that there is no indication that people who dropped out at various point during the study reported significantly different levels of well-being.

We then address the concern of our sample participants answering EMA prompts in a non-random manner by checking whether they systematically answered more prompts during different days of the week or at different times of the day. We check the distribution of answers across days of the week and find no significant differences ($\chi^2(6, 21718) = 10.94$, $p = 0.09$), suggesting that participants were equally likely to answer their EMA prompts on any day of the week. To check the distribution of answers throughout the day, we look at whether participants answered each of the five daily prompts in equal proportion. The first prompt was sent out between 9:00 local time and 11:30 local time, and each of the following prompts

was sent out in the next two-and-a-half-hour increment, until 21:30 local time. We find that reports are not evenly distributed across the day ($\chi^2(4, 21718) = 31.82$, $p < 0.01$), but a closer look at the numbers reveals that this difference is solely driven by lower responses to the first prompt of the day. Indeed, when checking the distribution after removing this first prompt, we no longer find a significant difference ($\chi^2(3, 17757) = 1.64$, $p = 0.65$). We suggest that this difference is due to the fact that participants may be missing out on the earliest notifications if they are still sleeping, and that the even distribution of reports throughout the rest of the day suggest that there is little observable non-randomness in terms of when participants fill out reports.

While we acknowledge that unverifiable systematic failure to answer certain EMA prompts may have occurred if participants were engaged in activities that caused them not to check their phone for an extended period of time, we argue that such trends would at least partially have been captured in the distribution of answered prompts across days of the week (for instance, as a difference in reports between weekdays and weekends) or time of the day.

We acknowledge that if the nature of people's thoughts, activity or company made it more or less likely for them to check their phone or answer their notifications, systematic non-randomness of recorded response may have influenced our results. However, as we have no way of definitively establishing the patterns of unobservable missing data, and based on our assessment of the data that we have available, we elect to treat missing reports as *missing at random* (Rubin, 1976) throughout this thesis.

Chapter 3:

It's not what you think – or is it? Exploring the effect of thoughts on subjective well-being

Abstract

We study how the type, valence and content of people's thoughts impact their experiences of purpose (worthwhileness) and pleasure (happiness). More than 20,000 experience sampling reports including momentary thoughts, activities and feelings were collected from 531 participants in a two-week longitudinal study. We demonstrate that previous lags of both the valence and content of thought predict experiences of happiness and worthwhileness. Attending to something other than the current activity lowers worthwhileness but has no effect on happiness. Our findings show that thoughts explain more of the within-person variation in well-being than activities do. Well-being enhancing self-help tools like mobile apps centred on people's internal experiences may benefit from incorporating these findings in their design.

Introduction

> *"The happiness of your life depends on the quality of your thoughts."*
> *– Marcus Aurelius*

We all pursue purpose and pleasure in our day-to-day experiences. They are both essential components of our subjective well-being. Following in the footsteps of many philosophers throughout human history, researchers and policymakers have shown increasing interest in well-being over the last decades. All agree that in order to understand what makes people happy – and their experiences worthwhile –, it is essential to consider both external factors and internal mechanisms. Yet, most of the focus has been on the external determinants of well-being (Diener et al., 1999; Dolan, 2014; Dolan & Kudrna, 2016; Pavot & Diener, 2009), like income, circumstances or activities (Dolan & Metcalfe, 2012; Kahneman et al., 2004; Lyubomirsky et al., 2005), as these are more easily observable and quantifiable than factors internal to individuals, like thoughts. Research on the internal determinants of well-being has explored a vast range of cognitive and attentional mechanisms as well, particularly through clinical and experimental studies (e.g., Ingram & Smith; 1984; Mrkva et al, 2019; Roberts & Danoff-Brug, 2010). However, there is still too little quantitative research about how momentary self-reported thoughts affect experiences of pleasure and purpose. In

particular, evidence is lacking on how different components of such thoughts interact to predict measures of well-being in general.

Correlational relationships between specific components of thoughts and happiness or anxiety exist (Marchetti et al., 2012; Andrews-Hanna et al., 2013; Blouin-Hudon & Zelenski, 2016) and a few longitudinal studies have looked at how these components of thoughts affect well-being over time (Killingsworth & Gilbert, 2010; Brose et al., 2011; Mills et al., 2021). Thoughts therefore matter for well-being, yet evidence from these studies is often ambiguous and sometimes contradicting. This is problematic, especially considering that some of these studies have been used to inform and justify the design of widely used self-help tools (particularly, mobile apps, see Bakker et al., 2016).

Previous research exploring the relationship between thoughts and well-being predominantly has emphasised the type of thoughts people report (Smallwood & Schooler, 2006; Mason et al., 2007). Researchers have used various terms (e.g., self-generated thoughts, mind wandering, task unrelated thoughts, stimulus-independent thoughts) that are conceptually similar (Watkins, 2008; Smallwood, 2013; Callard et al., 2013; Engert et al., 2014). Recent work has called into question the use of some of these terms depending on the context in which they are studied or how they are defined (Irving & Glasser, 2020; Murray et al., 2020; Seli et al., 2015). In the present paper, we will refer to the thoughts that we are interested in as task-unrelated thoughts, which we define as thoughts that occur when our attention is directed away from the activity that we are engaged in. These thoughts fall under the umbrella of what previous research has characterised as mind wandering (see Seli et al., 2018 for a more in-depth discussion). Task-unrelated thoughts (TUT) sit in contrast to thoughts related to the current activity (TCA) when attention is directed towards the external experience of what we are doing and who we are with.

TUT appear to be a ubiquitous aspect of people's day-to-day experiences, affecting things like task performance and learning (e.g., Brosowsky et al., 2021). While their occurrence varies depending on attentional and dispositional characteristics (Faber et al., 2018; Robison et al., 2020), studies have shown that TUT account for nearly half of all reported thoughts (Klinger & Cox, 1987; Killingsworth & Gilbert, 2010; Christoff et al., 2016) and find a negative relationship between the occurrence of TUT and the affective components of well-being (Choi et al., 2017; Killingsworth and Gilbert, 2010; Brose et al., 2011). However, to consider only the type of thought as a determinant of well-being fails to account for the complexity and multi-dimensionality of thoughts.

The remaining literature accounts for this complexity by focusing on the valence or content of TUT. Negative TUT are associated with worse well-being outcomes (Brose et al., 2011; Marchetti et al., 2012; Poerio et al., 2013; Smallwood & Andrews-Hanna, 2013), but positive TUT are related to better ones (Franklin et al., 2013; Schooler et al., 2014; Blouin-Hudon & Zelenski, 2016; Welz et al., 2018). There is scant evidence relating well-being to the valence of TCA, which begs the question of how type and valence interact with each other in predicting the different dimensions of well-being.

The content of thoughts matters too (Andrews-Hanna et al., 2013; Smallwood & Andrews-Hanna, 2013; Smallwood & Schooler, 2015; Welz et al., 2018). The study of content of TUT has focused on two main dimensions: a social and a temporal one. Past-related thoughts have been shown to negatively correlate with experienced well-being (Smallwood & O'Connor, 2011; Ruby et al., 2013; Poerio et al., 2013). Conversely, future-related thoughts tend to be beneficial for people's mood, especially when they are combined with self-related thoughts (Smallwood & O'Connor, 2011; Oettingen, 2012). Thoughts related to others also tend to have a positive impact on people's well-being (Poerio et al., 2015, 2016). Nyklíček and colleagues (2021) confirm these findings around past-, future- and others-related thoughts in an experience sampling dataset, however, they analyse the social and the temporal dimensions of thoughts separately, rather than incorporating them both in a single model. As such, it is unknown whether these findings replicate when considering these dimensions of thoughts simultaneously and in interaction.

The present study aims to (1) explore the relationship between several components of thoughts (i.e., type, valence, content), their interactions and momentary well-being; (2) establish the direction of the relationship between these components of thoughts and momentary well-being overtime; (3) compare the explanatory power of thoughts on momentary well-being to that of activities; and (4) look at these relationships in the context of hedonic (happiness) and eudemonic (worthwhileness) accounts of well-being. To this end, we conducted a two-week experience sampling study resulting in a panel dataset of 21,747 reports from 531 participants that includes more information on momentary thoughts than any previous longitudinal study. This allows us to discuss interaction effects and the lagged effects of thoughts on well-being in ways that previous papers were unable to do.

Our findings simultaneously confirm, challenge and complement the previous literature. While previous literature found that TUT have a negative impact on well-being, we find this negative effect only for worthwhileness and not for happiness. Lagged fixed effect models and Arellano-Bond estimators also reveal that previous reports of negative and

neutral valences of thoughts predict both happiness and worthwhileness, and that happiness is further caused by elements of type and content of thoughts. Moreover, components of thoughts explain more of the within-person variation in well-being than activities do, confirming our intuition that greater emphasis ought to be placed on thoughts as a determinant of well-being.

Methodology

Data collection

Data were collected as part of a larger study conducted by Telefonica Alpha[2] using the Reflections app, with approval of LSE's Research Ethics Committee. The Reflections app is a custom-made mobile app available on iPhone and Android that requires participants in the study to answer a set of daily questionnaires over the course of two weeks, when they are prompted by a notification. The questionnaires are based on experience sampling (or Ecological Momentary Assessment, EMA; see Shiffman et al., 2008), and ask people about their activities, their company, their thoughts and their well-being. From 9AM to 9:30PM local time, participants receive five notifications at random times during separate two and a half hour windows throughout the day and have a window of thirty minutes after each notification to open the questionnaire and answer it before it expires. The full EMA questionnaire is available in the supplementary materials (Appendix A1). Although this paper presents the results of a largely exploratory analysis, the data collection and main hypotheses of the larger study were preregistered on OSF (https://osf.io/yt745).

Participants

Participants were recruited among students and staff from the London School of Economics and Political Science (LSE) between January and February 2019. Given the exploratory nature of the study, no limit was set to the sample size prior to data collection. From the start of the study, students and staff had two weeks to sign up and take part in the study. The timeframe was determined to make sure that all data were collected during regular term time. During this time, 816 participants filled in the onboarding questionnaires, which consisted of a set of demographic questions, individual-specific characteristics questionnaires (i.e., self-esteem, big 5, delayed gratification, optimism, sense of control and attitude towards uncertainty) and general well-being questions. Participants were considered to have completed the study if they managed to complete over 70% of the daily EMA questionnaires and were paid £20 upon completion. Participants who did not manage to complete 70% of the

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[2] Now "Koa Health"

questionnaires were paid £5 for partial completion of the study (partial completion required them to complete at least the onboarding survey).

The present study considers all EMA entries in which participants reported at least one type of thought (i.e., TUT or TCA) alongside their experienced happiness *or* worthwhileness. Of the initial 816 participants, 285 either did not fill in a single EMA or failed to provide a single report satisfying these conditions. This results in a sample of 531 individual participants. This sample is composed of 81.0% of students (22 participants did not report their student status) and 65.3% of the participants were female (24 did not report their gender). While we did not ask for the participant's exact age, we know that 75.9% of participants are aged between 18 and 26, and less than 6.5% are older than 40 (21 did not report their age).

Measures & Coding

All variables of interest were taken from the EMA questionnaires. Participants were asked about their experienced happiness and worthwhileness using the questions *'How happy did you feel?'* and *'How worthwhile did this feel?'*. Both measures use an 11-point scale (0: Not at all – 10: Completely).

As part of the EMA, participants were first asked to enter their activity by answering the following question: '*What were you doing just now?*'. Then, they were asked how long they had been doing this for, followed by who they were with ('*I was with:*'), and then their thoughts. When reporting their thoughts, they completed the following statement: '*I was thinking about:*'. In all statements of activity, company and thoughts, participants could input as many answers as they wanted. As such, some participants reported more than one thought per entry. We take these reports to refer to thoughts that crossed their mind while participants were engaged in the activity that they reported.

Thought measures were split according to type, valence and content. For type, the variable TUT indicates when the participant reports a TUT in the given entry. This variable therefore takes a value of 1 when the participant was off-task, and 0 when they were on-task. TUT&TCA marks when the participant reports both a TUT and a TCA in the same entry, indicating that the participant's attention might have been split between on- and off-task thoughts around the time of the notification. A variable is also added to count the number of additional TUT that the participant reports in the given entry. We choose to keep this variable separate from the variable that indicates whether or not a participant reports a TUT because

we assume that the mechanism behind experiencing versus not experiencing a TUT is different from the mechanism that drives the experience of *one (or more) additional* TUT.

For valence, we create a variable for every answer (i.e., negative, neutral, positive), to account for the fact that participants may report thoughts of different valence in the same entry. We further add variables for the content of TUT, which we split between temporal and social content. The content of TCA was simply reported as "the current activity".

Construct	Variables	Scale	Description
Pleasure	*Happiness*	0-10	Answer to the question *'How happy did you feel?'*
Purpose	*Worthwhileness*	0-10	Answer to the question *'How worthwhile did this feel?'*
Type of thoughts	*TUT*	Binary	Equals 1 when any thought that is not *'Current activity'* is reported
	TUT&TCA	Binary	Equals 1 when both *'Current activity'* and another thought are reported in the same entry
	Additional TUT	Continuous	Is equal to the number of TUT reported on top of the first one
Valence of thoughts	*Positive, neutral, negative*	Binary	Equals 1 when a thought of the relevant valence is reported
Content of thoughts	*Self, others*	Binary	Equals 1 when the relevant social content of thought is reported
	Past, future	Binary	Equals 1 when the relevant temporal content of thought is reported
Activity	24 dummy variables (e.g., *working, studying, eating, commuting*, etc.)	Binary	Equals 1 when the relevant activity is reported
Company	6 dummy variables (e.g., *alone, colleagues, family,* etc.)	Binary	Equals 1 when the relevant company is reported

Table 4: Breakdown of dependent and independent variables, including scale and description.

The available options for the variables of thoughts, activity and company were chosen on the basis of a previous study among LSE students that made use of a similar app. Options were refined on the basis of frequency of selection in this previous study and an "add" option allowed participants to write down their own answer if it differed from the available selection. As stated previously, participants were allowed to select more than one answer for each of these questions. Prior to analysis, all added answers were manually recoded into existing categories (where applicable) or into new categories. This was the case for 5,230 out

of 30,370 reported activities, 747 out of 29,435 reported thoughts and 341 out of 25,086 reported company. In most cases, the added reports were just a different iteration of one of the available options. When a report did not seem to belong to any of the existing categories, it was classified as "other".

Coding of thoughts was further refined to distinguish between the social and temporal content of TUT. As such, TUT were split according to their social dimension between "Others", "Self" and no apparent social content, and according to their temporal dimension between "Future", "Past" and no apparent temporal dimension. Coding was done by the first author and approved by two co-authors before analysis.

The most extensive coding was done for reported activities. In addition to the 11 predefined options, activities were coded into the same categories as defined by Killingsworth and Gilbert (2010). This resulted in a list of 24 activities, including 21 of the original 22 as defined by Killingsworth and Gilbert (2010). The activity defined as "home computer" was replaced by "browsing internet" and two activities, "social media" and "studying", were added to account for sample-specific characteristics. Of this list of 24, "making love" was dropped from our analysis, as it was only reported a total of 5 times. The company variable was split into the 6 most recurring answer categories (i.e., "alone", "friends", "colleagues", "partner", "family", "strangers").

Descriptive statistics

Across the 531 participants in our full sample, the mean completion rate of EMA is 58.5% (40.9 reports out of a possible 70) while the median completion rate is 72.9% (51 out of 70 reports), resulting in a full sample of 21,747 unique EMA entries. A total of 29,435 thoughts were reported across the EMA entries, of which 11,786 are TUT (40.0%), which is similar to previous studies on related phenomena (Klinger & Cox, 1987; Killingsworth & Gilbert, 2010). The percentage of entries that contained TUT reports was slightly lower accounting for 38.5% of the reports (8,375 out of 21,747).

Of the 21,747 entries, 5,799 entries do not include reports of experienced worthwhileness and 5,846 entries do not include reports of experienced happiness. 9 out of 531 participants failed to fill in at least one report of experienced worthwhileness, and 7 failed to fill in at least one report of experienced happiness. As a result, the sample used to analyse experienced happiness is composed of 524 individuals and 15,901 unique entries, and the sample used to analyse experienced worthwhileness of 522 individuals and 15,948 unique entries. In these respective samples, the mean experienced happiness is 6.34 (SD = 1.93) and

the mean experienced worthwhileness is 6.35 ($SD = 2.18$). Table 2 shows a more in-depth breakdown of descriptive statistics. Descriptive statistics for TUT content variables are shown using the subsample of entries containing TUT reports.

In addition, we note that participants reported on average 1.3 thoughts per entry ($SD = 0.78$). The large majority of reports (77.6%) contained only one thought. Two thoughts were reported simultaneously 13.8% of the time, and three thoughts 5.6% of the time. TUT and TCA were reported simultaneously 19.6% of the time.

Variable	Min	Max	N	Mean	SD
Well-being					
Happiness	0	10	15,901	6.34	1.93
Worthwhileness	0	10	15,948	6.35	2.18
Thoughts					
TUT	0	1	21,747	0.39	0.49
TCA	0	1	21,747	0.81	0.39
Negative	0	1	21,747	0.14	0.34
Neutral	0	1	21,747	0.43	0.50
Positive	0	1	21,747	0.56	0.50
TUT content					
Social: self	0	1	8,375	0.35	0.48
Social: others	0	1	8,375	0.28	0.45
Temporal: past	0	1	8,375	0.23	0.42
Temporal: future	0	1	8,375	0.45	0.50

Table 5: Descriptive statistics for thought and well-being variables.

Statistical methodology

We use fixed effect models to separate the within-person effect of the thought variables on well-being from the individual fixed effects. We distinguish between two levels of precision when it comes to thought components. That is, we first look at models including the type, valence and content of thoughts that participants report. Subsequently, we expand the equation to include the interaction effects between variables of type and valence, and between social and temporal dimensions of content. As such, the basic model looks as follows:

$$(1) \quad well\_being_{it} = \beta_1 TUT_{it} + \beta_2 TUT\&TCA_{it} + \beta_3 pos_{it} + \beta_4 neut_{it} + \beta_5 neg_{it} + \beta_6 add\_TUT_{it} + EE_i + e_{it}$$

, where EE_i captures the entity effects (or fixed effects) for each individual participant i, t denotes every unique entry for said participant and e_{it} is the error term. Valence reports are denoted by the dummies pos_{it}, $neut_{it}$ and neg_{it}. To this model, we add the variables relating to the social and the temporal content of TUT, as well as interaction terms (as described above).

To establish whether there is a Granger causal link[3] (see Granger, 1969) between thought variables and within-person variations in experienced well-being measures, we use the thought components reported in the previous entry *from the same day* as explanatory variables and include a lag of the well-being variable to the model. Accordingly, this reduces the number of observations to 10,608 for experienced happiness and 10,675 for experienced worthwhileness for these particular models. To account for the lagged structure of the data and to deal with endogeneity issues that come with using a lag of the dependent variable, we use Arellano-Bond dynamic panel estimators[4] (see Roodman, 2009) on top of the fixed effect models. The resulting dynamic model for t-1 looks as follows:

$$(2) \quad well\_being_{it} = \beta_1 TUT_{it} + \beta_2 TUT\&TCA_{it} + \beta_3 pos_{it} + \beta_4 neut_{it} +$$
$$\beta_5 neg_{it} + \beta_6 add\_TUT_{it} + \beta_7 well\_being_{i(t-1)} + \beta_8 TUT_{i(t-1)} + \beta_9 TUT\&TCA_{i(t-1)} +$$
$$\beta_{10} pos_{i(t-1)} + \beta_{11} neut_{i(t-1)} + \beta_{12} neg_{i(t-1)} + \beta_{13} add\_TUT_{i(t-1)} + EE_i + e_{it}$$

, where *well_being*$_{i(t-1)}$ is the auto-regressive lag of experienced happiness or worthwhileness. We further add the variables relating to the social and the temporal content of TUT at *t* and *(t–1)*.

Finally, we run the regular fixed effect models using variables relating to activity as independent variables, to compare the explanatory power of thoughts relative to activities on within-person variations in experienced well-being. These models include dummies for each reported activity and each reported company. All statistical tests were performed using STATA (SE 17.0).

Results

Experienced happiness

We find no significant relationship between TUT and experienced happiness in our models with or without interactions. This finding contrasts the previous literature, which

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[3] According to Granger causality, an independent variable can be said to cause (or, Granger-cause) a change in a dependent variable if a previous lag (t-1) of the independent variable significantly predicts a change in the dependent variable (at t), *over and above* the effect of the previous lag of the dependent variable (t-1). As such, if we are interested in the Granger causal effect of thoughts on well-being, thoughts at t-1 must significantly predict changes in well-being at t, *accounting for* well-being at t-1 as a predictor of well-being at t (Granger, 1964 for a more in-depth discussion).

[4] The Arellano-Bond estimator is a generalised method of moments (GMM) estimator that accounts for the endogeneity that arises when a lag of the dependent variable is included as a predictor of the dependent variable. The endogeneity arises at the level of individual fixed effects and the error term, and is addressed by taking the first difference of the model, which removes the individual fixed effects, and then using second and third lags of the dependent variable as instruments for the first lag. In the absence of second-level autocorrelation of residuals (AR(2)), this addresses the endogeneity created by the correlation between the dependent variable and the error term. The present paper uses that xtabond2 command in Stata as outlined in Roodman, 2009 (see for more in-depth discussion).

associates TUT with unambiguously negative effects on well-being (Killingsworth and Gilbert, 2010; Brose et al., 2011), and suggests a more nuanced take on the relationship between thoughts and experienced happiness.

Furthermore, reporting both TUT and TCA in the same entry is associated with a significant increase in experienced happiness (b=0.261, p<0.001), and every additional TUT reported on top of the first one is associated with an increase in experienced happiness (b=0.109, p=0.007), although these associations become insignificant when including interaction terms. As such, the relationship between TUT and reported happiness is less straightforward than is often suggested in the literature. Indeed, simply allowing people to report TUT alongside TCA already introduces a scenario in which TUT may actually be beneficial for people's experienced happiness.

Valence of thoughts has a larger and more consistent effect on experienced happiness. Across all three models, we find a strong positive relationship between thoughts of positive valence and experienced happiness (b=[0.414, 0.948], p<0.001), and a strong negative relationship between thoughts of negative valence and happiness (b=[-0.616, -1.395], p<0.001). However, we see that this relationship is different for different types of thoughts. We observe the largest positive and negative coefficients for positive and negative TCA (b=0.703 and b=-0.930, respectively, p<0.001), while positive TUT are also positively related to experienced happiness (b=0.520, p<0.001). Negative TUT are not significantly related to experienced happiness. More generally, people report more extreme experiences of happiness (i.e., higher when valence is positive, lower when negative) when they attend to their current activity than when their attention is off-task. Coefficients, significance levels and clustered standard errors are shown in table 6.

DV: Exp. happiness	(1)	(2)
Type (base: TCA)		
TUT	-0.073 (0.052)	0.011 (0.065)
TUT & TCA	0.261*** (0.052)	-0.052 (0.068)
Valence		
Positive	0.948*** (0.064)	0.414*** (0.076)
Neutral	-0.232*** (0.054)	-0.053 (0.066)
Negative	-1.379*** (0.067)	-0.616*** (0.169)
Additional TUT	0.109** (0.041)	0.041 (0.045)
Social content (base: Not specified)		
Others	-0.010 (0.060)	-0.051 (0.066)
Self	-0.054 (0.051)	-0.293** (0.102)
Temporal content (base: Not specified)		
Past	-0.119 (0.064)	-0.224** (0.074)

Future	-0.072 (0.048)	-0.146* (0.062)
*Type*Valence*		
TUT* Positive		0.520*** (0.069)
TUT*Negative		-0.298 (0.174)
TCA*Positive		0.703*** (0.079)
TCA*Negative		-0.930*** (0.152)
*Social * Temporal content*		
Self * Past		0.133 (0.108)
Self * Future		0.282* (0.121)
Others * Past		0.153 (0.113)
Others * Future		-0.006 (0.093)
N. of observations (entries)	15901	15901
N. of entities (individuals)	524	524
F-test	152.60	97.080
R²	0.2582	0.2740

Table 6: Regression coefficients, significance (: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models on experienced happiness for (1) basic model without interactions, and (2) model including interactions between type and valence, and social and temporal dimensions of content.*

Finally, we see that most variables of content of thought are not significantly related to experienced happiness across either model, although our interaction model confirms prior findings that past-related thoughts have a negative association with experienced happiness. The interaction model also shows that future- and self-related thoughts have a significantly negative association with experienced happiness when they are considered independently from each other, but that the interaction between self- and future-related thoughts largely offsets this negative relationship, which is also in accordance with past findings (Smallwood & O'Connor, 2011; Oettingen, 2012).

We note that our models differ from the literature that found negative associations between TUT and happiness mainly in that we include content of thoughts, while previous studies did not. We therefore also run a simplified version of our models, including only variables of type and valence of thoughts, and find that these models replicate previous finding, as they show a significant negative relationship between TUT and happiness (p < 0.01). This further emphasises the importance of considering content alongside type of thoughts, and explains why previous literature found and reported a negative association between TUT and happiness. These additional models can be found in the supplementary materials (Appendix A2).

These findings showcase the importance of analysing components of thoughts jointly rather than independently. In fact, our full regression model shows no significant coefficients for any of our variables measuring the type of thought alone. In other words, attending to

something other than the current activity is not a bad thing in and of itself. Instead, we find that the negative association between TUT and happiness is fully captured by the content of these TUT, and that valence of thoughts is a much stronger overall predictor of experienced happiness.

Our analysis further shows that the importance of interactions between type and valence of thoughts. Where the previous literature has completely overlooked this interaction, it turns out that the valence of TCA is a much stronger predictor of experienced happiness than the valence of TUT, both in terms of the magnitude and significance of the effects. Indeed, while positive TCA are associated with the highest experienced happiness reports, negative TCA are associated with the lowest ones, further challenging the previously well-established notion that TCA are preferable to TUT.

Experienced worthwhileness

We find similar relationships between valence of thoughts and experienced worthwhileness, where negative TCA show the largest negative association with experienced worthwhileness (b=-0.991, p<0.001) and positive TCA the largest positive association (b=0.592, p<0.001). Negative TUT (b=-0.487, p=0.029) and positive TUT (b=0.442, p<0.001) are also significantly related to experienced worthwhileness, confirming the importance of valence of thoughts as a predictor of experienced well-being in general.

While valence is similarly related to both well-being measures, the relationship with variables of type and content of thoughts differed substantially from happiness to worthwhileness. Indeed, we observe that TUT have a significant negative relationship with experienced worthwhileness across both models (b=[-0.278, -0.215], p<0.001 to p=0.014), and that the coefficient of additional TUT reports is not significant. The coefficients for all models are shown in table 7.

DV: Exp. worthwhileness	(1)	(2)
Type (base: TCA)		
TUT	-0.278*** (0.072)	-0.215* (0.087)
TUT & TCA	0.349*** (0.064)	0.109 (0.091)
Valence		
Positive	0.675*** (0.070)	0.205* (0.084)
Neutral	-0.336*** (0.062)	-0.207* (0.082)
Negative	-1.140*** (0.074)	-0.280 (0.214)
Additional TUT	-0.026 (0.048)	-0.077 (0.052)
Social content (base: Not specified)		
Others	0.091 (0.071)	0.017 (0.083)
Self	0.179* (0.079)	0.028 (0.168)

Temporal content (base: Not specified)		
Past	0.042 (0.076)	-0.035 (0.082)
Future	-0.004 (0.071)	-0.052 (0.075)
Type*Valence		
TUT*Positive		0.442*** (0.094)
TUT*Negative		-0.487* (0.223)
TCA*Positive		0.592*** (0.096)
TCA*Negative		-0.991*** (0.221)
Social * Temporal content (base: Not specified)		
Self * Past		0.010 (0.140)
Self * Future		0.186 (0.175)
Others * Past		0.224 (0.157)
Others * Future		0.017 (0.116)
N. of observations (entries)	15948	15948
N. of entities (individuals)	522	522
F-test	76.73	45.99
R²	0.1249	0.1345

Table 7: Regression coefficients, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models on experienced worthwhileness for (1) basic model without interactions, and (2) model including interactions between type and valence, and social and temporal dimensions of content.

We see that self-related thoughts are significantly positively related to experienced worthwhileness (b=0.179, p=0.023), but only in the model without interactions. Aside from this, no content variable has a significant relationship to experienced worthwhileness, suggesting that, unlike experienced happiness, it is the occurrence of a TUT that matters for experienced worthwhileness, regardless of its content. Figure 5 showcases this difference by providing a summary of the sign, magnitude, and significance of the coefficients of type and content of thoughts on experienced happiness and worthwhileness in the most complete model (i.e., including interactions).
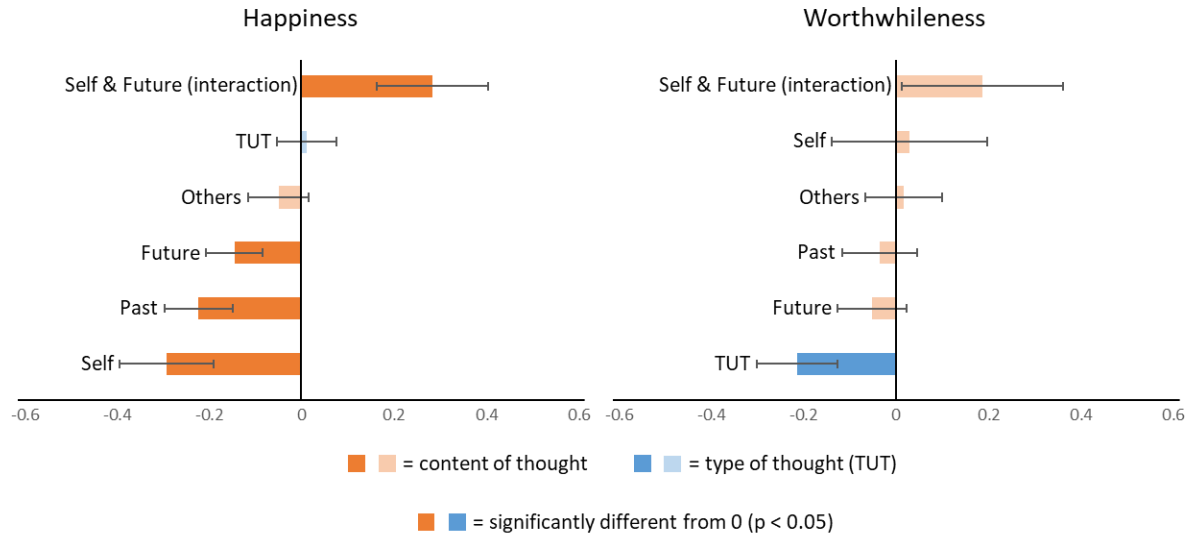
Figure 5: Graphical representation of sign, magnitude and significance of the effect of type and content of thought on experienced happiness and worthwhileness, including clustered standard errors in the models with interaction effects.

It appears that attending to something other than the current activity is detrimental to people's experienced worthwhileness. In other words, shifting one's attention away from the current activity might negatively affect one's worthwhileness regardless of the content of the internal experience. We also see that our models explain up to 27.40% of the variation in experienced happiness, while they explain only up to 13.45% of experienced worthwhileness, suggesting that thoughts and their components are more important to people's experienced happiness than worthwhileness.

Testing for Granger causality

We further expand our analysis to check for Granger causal links between any of these components of thoughts and experienced well-being. For this, we add time lags for every variable corresponding to the previous EMA report from the same day, in each of our previously tested models. In addition, we run Arellano-Bond dynamic panel estimations to account for the endogeneity introduced by using a lag of the dependent well-being variable. Including a lag of the dependent variable allows us to establish that any significant lagged variables contribute to predicting reports of well-being above and beyond previous lags of well-being. The resulting coefficients, significance levels and clustered standard errors for both experienced happiness and worthwhileness are shown in table 8. Time lag models including interactions between valence and type, and social and temporal dimensions of content were not reported, since none of the lags of interaction variables showed significance

and the models did not show any meaningful differences with those shown in table 8. Hence, we focus on the discussion of the main effect of each thought variable.

DV: Exp. well-being	(1)	(2)	(3)	(4)
Type (base: TCA)				
TUT	-0.084 (0.061)	-0.182** (0.060)	-0.360*** (0.076)	-0.490*** (0.076)
TUT & TCA	0.247*** (0.061)	0.339*** (0.058)	0.395*** (0.078)	0.531*** (0.075)
Valence				
Positive	0.798*** (0.060)	0.989*** (0.063)	0.603*** (0.077)	0.760*** (0.081)
Neutral	-0.276*** (0.056)	-0.350*** (0.056)	-0.281*** (0.072)	-0.443*** (0.072)
Negative	-1.187*** (0.061)	-1.433*** (0.064)	-0.947*** (0.079)	-1.245*** (0.083)
Additional TUT	0.138** (0.045)	0.222*** (0.046)	-0.133* (0.056)	-0.027 (0.059)
Social content (base: Not specified)				
Others	0.056 (0.066)	0.033 (0.067)	0.343*** (0.084)	0.160 (0.083)
Self	-0.040 (0.064)	0.028 (0.060)	0.264** (0.082)	0.281*** (0.080)
Temporal content (base: Not specified)				
Past	-0.060 (0.071)	-0.068 (0.076)	0.163 (0.087)	0.152 (0.091)
Future	-0.087 (0.063)	-0.100 (0.060)	-0.053 (0.080)	0.029 (0.077)
Lagged variables				
Happiness (t-1)	-0.234*** (0.012)	-0.003 (0.031)		
Worthwhileness (t-1)			-0.247*** (0.012)	0.045 (0.030)
Type (t-1)				
TUT (t-1)	0.025 (0.061)	-0.065 (0.060)	0.007 (0.077)	0.043 (0.075)
TUT & TCA (t-1)	0.169** (0.061)	0.205** (0.060)	0.062 (0.080)	-0.006 (0.078)
Valence (t-1)				
Positive (t-1)	0.086 (0.061)	0.110 (0.068)	0.061 (0.078)	0.055 (0.081)
Neutral (t-1)	-0.212*** (0.057)	-0.260*** (0.056)	-0.164* (0.073)	-0.264*** (0.074)
Negative (t-1)	-0.518*** (0.063)	-0.472*** (0.075)	-0.418*** (0.081)	-0.381*** (0.090)
Additional TUT (t-1)	0.094* (0.044)	0.113** (0.043)	0.046 (0.061)	0.105 (0.055)
Social content (t-1)				
Others (t-1)	-0.089 (0.069)	-0.099 (0.071)	0.037 (0.090)	-0.089 (0.088)
Self (t-1)	-0.076 (0.065)	0.033 (0.063)	0.103 (0.083)	-0.061 (0.082)
Temporal content (t-1)				
Past (t-1)	-0.200** (0.069)	-0.147* (0.072)	-0.090 (0.089)	-0.053 (0.086)
Future (t-1)	-0.088 (0.064)	-0.033 (0.061)	-0.016 (0.081)	0.126 (0.078)
N. of obs (entries)	10608	10608	10675	10675
N. of entities	4232	4232	4269	4269
F-test	111.42	NA	58.82	NA
R²	0.2692	NA	0.1621	NA
Hansen test	NA	p=0.136	NA	p=0.430
AR(1)	NA	p<0.001	NA	p<0.001
AR(2)	NA	p=0.145	NA	p=0.316

Table 8: Regression coefficients, significance (: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of (1 & 3) the fixed effects model including time lags for t-1, and (2 & 4) the equivalent Arellano-Bond dynamic panel estimation, using one-step system GMM (Generalized Method of Moments) for happiness (1 & 2) and worthwhileness (3 & 4).*

We find that reporting a TUT alongside a TCA at t-1 predicts experienced happiness at t to increase by 0.205 (p=0.001), and that reporting additional TUT on top of the first one at t-1 also significantly increases experienced happiness at t (b=0.113, p=0.008). Furthermore, reporting a neutral or a negative thought at t-1 predicts experienced happiness to be significantly lower at t (b=-0.260 and b=-0.472, respectively, p<0.001). However, reporting a positive thought at t-1 does not appear to predict happiness levels at t, suggesting that non-positive thoughts have a longer-lasting impact on experienced happiness. Furthermore, including lagged coefficients rendered all the effects of socio-temporal content variables insignificant at t, although we observe that past-related thoughts at t-1 predict a significant decrease in experienced happiness at t (b=-0.147, p=0.040).

We run the same analysis using experienced worthwhileness and find that only thoughts of neutral and negative valence at t-1 have a significant negative effect on experienced worthwhileness at t in both models (b=-0.264 and b=-0.381, respectively, p<0.001, in Arellano-Bond model), suggesting that the Granger causal relationship between thought components and experienced worthwhileness is less evident than for experienced happiness. While these findings do not rule out the possibility that TUT in the moment causally impact experienced worthwhileness, we conclude that the type of thought does not have a long-lasting effect on experienced worthwhileness. Figure 6 provides a summary of the Granger causal relationships as discussed above.
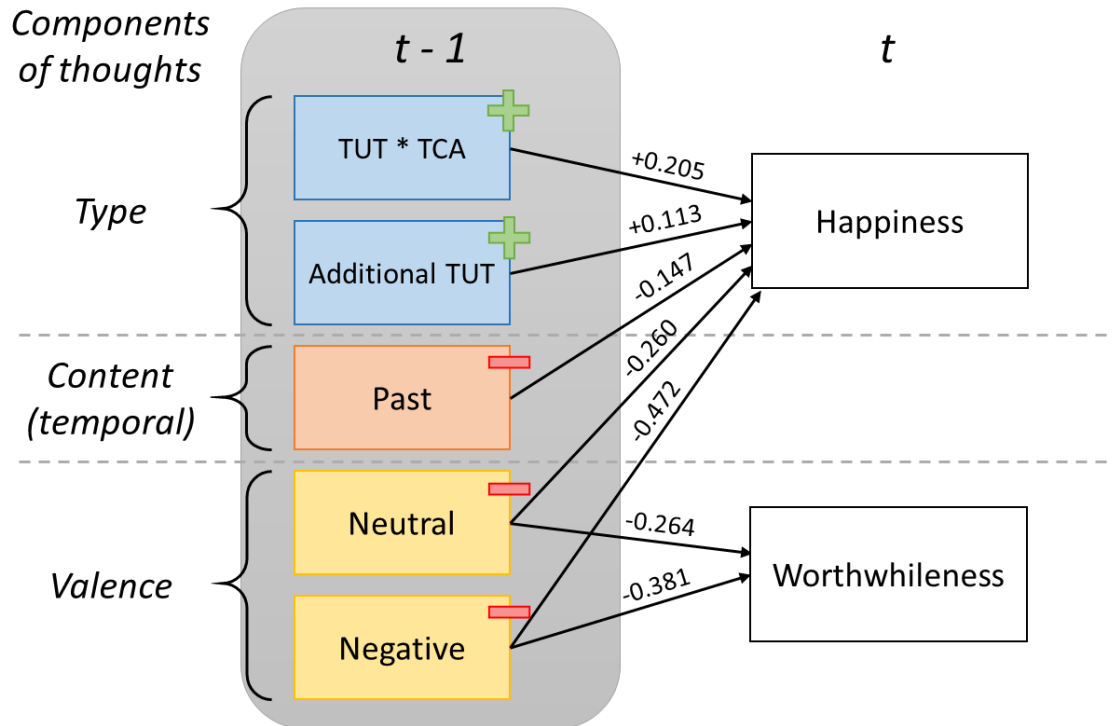
Figure 6: Breakdown of the Granger causal effects between thought components and experienced well-being, including sign and magnitude of the effects of thought components on experienced happiness and worthwhileness. All effects are significant at p<0.05. Coefficient are taken from the Arellano-Bond dynamic panel estimations.

At t, we see that having a TUT now has a significant negative effect on happiness, but only when using the Arellano-Bond estimations (b=-0.182, p=0.002). We also note that the magnitude of the significant positive effects of reporting a TUT alongside a TCA and of reporting an additional TUT increased in response to the increased negative effect of only reporting a TUT. We further see that self-related thoughts at t are now positively related to worthwhileness (b=0.281, p<0.001). In addition to our analysis on t-1 variables, we also replicated Killingsworth and Gilbert's (2010) checks using t+1 variables. A short discussion of these models can be found in the supplementary materials (Appendix A2).

Thoughts versus activities

Having shown how the component of thoughts impact both pleasure and purpose, we turn to people's reported activities and company to put the effect of thoughts into perspective. The fixed effects model including both activities and company explains 8.72% of the variation in experienced happiness and 10.45% of the variation in experienced worthwhileness. As such, we find that our self-reported measures of thoughts are better predictors of experienced well-being than self-reported activities, which further highlights the importance of considering thoughts as central to models outlining determinants of well-being. We find that thoughts and activities jointly explain 30.62% of experienced happiness and

21.59% of experienced worthwhileness, indicating that there is some overlap in the variation in experienced well-being that is explained by each factor. Figure 7 shows the breakdown of the explanatory power of thoughts and activities on experienced happiness and worthwhileness. Regression tables and additional analysis on the relationship between our thought variables and activities can be found in the supplementary materials (Appendix A2).
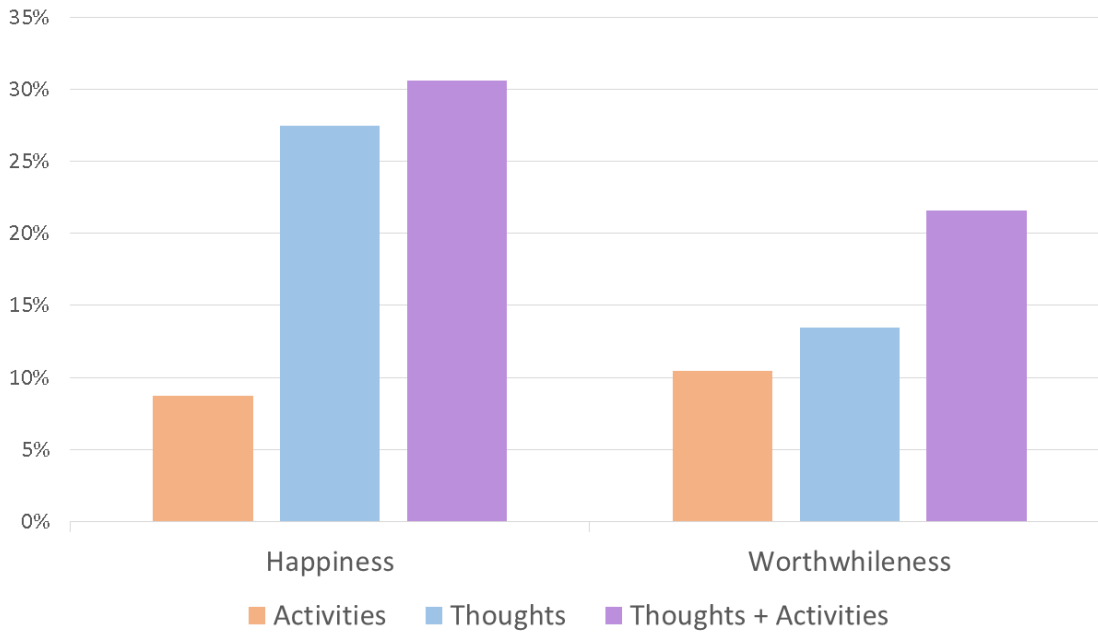
Figure 7: Graphical representation of the within-person variance in experienced happiness and worthwhileness explained by activities, thoughts, and thoughts + activities, respectively.

Discussion

Recent decades have seen advances in our understanding of the relationship between thoughts and well-being, some of which have been applied to design various types of well-being enhancing interventions (e.g., Killingsworth & Gilbert, 2010). While this trend is encouraging, it means that we need to be confident about the nuances of the role that thoughts play in determining well-being. Our results show that not attending to the current activity is not *per se* detrimental to our affective well-being (Andrews-Hanna et al., 2013; Mrazek et al., 2012; Stawarczyk et al., 2012; Welz et al., 2018). Instead, we find that TUT can have positive effects on experienced well-being. We also find that content matters (Smallwood & Andrews-Hanna, 2013; Smallwood & Schooler, 2015; Nyklíček et al., 2021). Our models including interactions between social and temporal content of thoughts showed that, while TUT do not significantly relate to happiness, several aspects of content do, suggesting that what matters is not only whether attention is directed towards on-task or off-task thoughts, but rather, the specific content of the thought. Specifically, our present findings are broadly

aligned with Smallwood and Andrews-Hanna's (2013) content-regulation hypothesis, as we find that past-related thoughts indeed tend to be negatively associated to well-being, although the relationship between future-related thoughts and happiness remains more ambiguous.

Our findings also confirm the importance of valence of thoughts in determining experienced well-being. Where the previous literature had only looked at the valence of TUT, we show that valence is associated with more variation in well-being among TCA than TUT. This further calls into question the idea that TCA in general are better for our well-being than TUT. Based on these findings, we suggest that TUT may function as a "dampening" mechanism for our well-being experiences, making negative experiences of the current activity comparably less negative by drawing our attention away from it (see also Shepherd, 2019). TUT may play a similar role to external distractions, which have been shown to have a positive effect on the individual's experience when they are engaged in an unpleasant activity, but a negative effect when they are engaged in a pleasant one (Isikman et al., 2016). As such, it is the context in which the type of thought occurs, as well as its content, that would determine whether it is beneficial to our happiness, rather than the type of thought.

Our Granger causal results show that reporting both TUT and TCA or reporting multiple TUT during an activity has lasting positive repercussions on experienced happiness, prompting us to caution intervention designers against telling people to avoid TUT altogether (see also Stawarczyk et al., 2012; Welz et al., 2018). Instead, our findings suggest that individuals seeking to increase their momentary happiness may be better off focusing on the content of their thoughts, rather than on whether they are attending to their current activity.

The findings related to the co-occurrence of TUT and TCA in our models without interactions further raise the question of how we ought to interpret the reporting of several thoughts in the same questionnaire. The perspective we take in this study is that people may sometimes experience several thoughts simultaneously, or in quick succession, and that restraining their self-reports to a single thought therefore artificially limits their ability to report what they are actually thinking about at the moment of the notification (see also, Nyklíček et al., 2021). For example, one participant who reported to be walking (activity) with their kids (company) reported thinking both about their current activity and about "events from the past days". Another one, while shopping (activity) alone (company), reported thinking about their current activity and about their partner. In both cases, it is plausible that the participant's attention was split between their activity and an unrelated thought, especially since the activity was not one that appeared to require the participant's full attention.

Overall, TCA and TUT were reported simultaneously 19.6% of the time, suggesting that people regularly split their attention between external and internal experiences throughout their day-to-day lives. The fact that we find significant associations between this co-occurrence of TCA and TUT and well-being measures further illustrates how nuanced the relationship between thoughts and well-being really is. While our present findings are not sufficient to draw robust conclusions regarding where this co-occurrence of TCA and TUT sits in relation to the rest of the literature on mind wandering, future research should explore the mechanisms that drive it and how it relates to indicators of well-being, using both experimental and experience sampling designs.

TUT are negatively related to experienced worthwhileness across all our models, indicating that attending to our current activity may be more important for eudemonic as opposed to hedonic well-being. This could be explained by the way people experience purpose relative to pleasure. While pleasure is strongly dependent on people's internal experiences of the moment, as shown by the explanatory power of thought variables on experienced happiness, purpose draws upon prior evaluations of contextual factors, such as activities, to determine whether the experience of the moment is a worthwhile one. As such, the purpose derived from the moment relies more on people's preconceived awareness that this moment contributes to their life in a meaningful way, therefore providing them with a worthwhile experience. The significant negative relationship with TUT can then be explained by the fact that attending to the current activity may be more closely tied to this preconceived awareness of the worthwhileness of the activity.

Our results further highlight the importance of considering the purpose component of well-being in the study of thoughts. While we find that the components of thoughts tend to be relatively better predictors of pleasure, their effect on experienced happiness is far from indicative of their effect on experienced worthwhileness (see also, White & Dolan, 2009). It follows that the apparent lack of evidence on the relationship between thoughts and purpose may have caused an improper understanding of the role of thoughts in determining experienced well-being among social scientists. For example, future- or self-related thoughts have a negative effect in isolation, but a joint positive effect on experienced happiness, while self-related thoughts may have a positive effect on experienced worthwhileness. Taken together, they suggest that encouraging people to think about their future selves may be beneficial for their well-being in general. Interventions seeking to increase people's overall well-being should be mindful of these differences, and further research on this relationship would benefit from including the eudemonic component of well-being.

We further find that other components of thoughts have a Granger causal effect on happiness and worthwhileness. Notably, reporting a neutral or a negative thought at t-1 causes experienced happiness and worthwhileness to be significantly lower at t, indicating that negative and neutral thoughts have longer lasting effects on well-being than positive ones. This is also in line with the way people experience positive versus negative events in their lives (Diener et al., 2009). Interventions focusing on reducing the amount of negative thoughts may therefore be a powerful tool to improve people's well-being. We also observe that thoughts related to the past have a persisting negative effect on experienced happiness. Therefore, encouraging people to move away from past-related thoughts may contribute to increasing their experienced happiness.

These findings do not rule out more complex causal relationships between thought components and well-being, but they confirm the previous intuition that several elements of type, valence and content of thoughts could cause changes in experienced well-being (Killingsworth & Gilbert, 2010). One possible caveat of the present study is that, even though only previous lags of thoughts *during the same day* were considered, two subsequent EMA notifications were, on average, separated by two and a half hours, which begs the question of whether any momentary thought can reasonably be said to impact how people feel over two hours later. It may therefore be that the longitudinal relationships that we observe are the result of unobserved variables. Further research would need to use appropriate experience sampling to capture thoughts and well-being at even shorter time intervals to capture the momentary elements of this Granger causal relationship more accurately. It must also be said that while applying lagged estimators using longitudinal panel data is a good approximation of causality, it does not allow for the same kind of causal inference as experimental designs do, and future research may therefore attempt to isolate these causal relationships using different study designs.

We acknowledge that our study is limited by the design features of longitudinal EMA studies, namely selection bias, in terms of who selected to participate in the study and which participants chose to drop out along the way, and reliance on self-reports. Notably, we find no significant differences in terms of individual-specific characteristics or well-being indices between participants and people who dropped out after the onboarding survey, except for the fact that people who dropped out after the onboarding reported slightly higher levels of anxiety than the participants who chose to remain in the study ($p < 0.01$). A more in-depth discussion of attrition in our sample can be found in the supplementary materials (see chapter 2 and general discussion). Despite these limitations, EMA remains the most robust and

widely accepted way to capture people's momentary well-being and thoughts over time and in an ecologically valid setting (Smallwood & Schooler, 2015).

In addition, because the relationship between thoughts and well-being was not the main aim of the larger study that these data were collected for, the format of the EMA questions used in this study differs slightly from the one that was used in previous studies, as participants were allowed to report multiple thoughts, rather than just one. While we have discussed the co-occurrence of TCA and TUT above, we cannot rule out the possibility that some people might have reported thoughts that were not just pertaining to the moment of the notification, but rather, to the activity that they reported more generally. While the similarity of our findings compared to the previous literature suggests that this did not cause a drastic shift in the way participants reported their thoughts, it is difficult to assess how this might have impacted reports of TUT. Given that both variables related to the number of TUT and to the interaction between TUT and TCA significantly predicted well-being in several of our models, future research should weigh the pros and cons of allowing people to report multiple thoughts in EMA-like questionnaires or methodologies.

The precise formulation of the thoughts question also matters when determining the proper terminology for the types of thoughts that are captured. In this paper, we opted to label these thoughts "task-unrelated thoughts", defining them as thoughts that occur when attention is directed away from the current activity. It must be noted, however, that this definition is not exactly equivalent to the way task-unrelated thoughts are defined in the experimental literature, where the presence of a task is always predetermined and unambiguous. In the context of day-to-day activities, it is not always clear what makes a task, or whether all daily life activities involve "tasks" at all (see Murray et al., 2020). As such, it may have been more accurate, strictly speaking, to label the thoughts that were measured in this study as "activity-unrelated". Following Seli et al.'s (2018) family-resemblances view of mind wandering, we argue that while there may be subtle differences in how task-unrelated thoughts are measured between experimental and ecologically valid settings, the contexts in which these thoughts are measured (i.e., in opposition to a well-defined activity or task) show sufficient similarities to justify the use of a common, widely accepted terminology.

Finally, we are limited by the fact that our sample is composed of university staff and students, and all findings may thus not be generalizable to the general population. While similarities between our findings and the previous literature (particularly in our first fixed effects models and with regards to content of thought) point to the applicability of our

findings to different populations, we encourage further research to replicate our findings in different socio-demographic contexts.

Nonetheless, we propose that our findings could be incorporated into self-help interventions that are designed to improve well-being. Indeed, despite the fact that other studies have hinted at the potential benefits of TUT and mind wandering (Baird et al., 2012; Smallwood & Andrews-Hanna, 2013; Corballis, 2015), the vast majority of tools available to the general population (apps, books, podcasts, etc.) still aim to reduce the occurrence of such thoughts, rather than to understand their potential benefits. Importantly, our findings do not contradict such interventions, but rather shed light on how to complement existing interventions by leveraging the benefits of TUT and mind wandering.

For instance, mindfulness interventions that foster a greater attention to the present (Marlatt & Kris-teller, 1999, p. 68) could also be designed to encourage individuals to attend to their internal experiences, even when these are not necessarily aligned with the external experiences of the current activity. This is all the more relevant considering that research has shown that not all people benefit from mindfulness interventions as they are currently conceived (Kaufmann et al., 2021; Van Dam et al., 2018). Similarly, a great deal of interventions (including components of CBT, e.g., Bennett-Levy, 2003; Rees et al., 2003) that have been designed around recognising and dealing with intrusive thoughts could be adapted to help individuals focus on beneficial types and contents of thoughts. Overall, considering the evidence from our study, we support the development of tools that do not simply prescribe certain types of thoughts or ways of thinking but that guide people towards a better understanding of how their thoughts might impact their experiences of purpose and pleasure.

Our present findings can be used as a stepping-stone for further research into the mechanisms underlying the occurrence of mind wandering and the resulting impact on well-being. As we show that the effects of components of thoughts are best understood and interpreted simultaneously and in interaction, we call for researchers in this area to avoid focusing on a single component of thoughts and to consider how these components of thoughts interact with each other. This could go some way towards building an overarching thought theory of well-being that accurately reflects the complexity of the relationship between thoughts and well-being. We also encourage future research to use similar data collection and analysis methods to further deepen our understanding of the causal relationships between thoughts and well-being. Future research could focus on other

dimensions of well-being, such as experienced negative affect, which was not reported as part of this study, or different variations of components of thoughts.

In short, thoughts matter, and so do their components. We conclude that our models including thoughts as major determinants of within-person variation in experienced well-being better explain this variation than people's activities, and that this inclusion is necessary to properly understand the internal factors that cause changes in well-being in general. The next step, then, is to use this as a basis to incorporate thoughts into broader models that also explain between-person variation in well-being, and to determine the extent to which thoughts predict the various dimensions of experienced and evaluative well-being relative to their other known determinants.

Chapter 4:

Me, my thoughts and I – Personality as a moderator of the effect of thoughts on subjective well-being

Abstract

We study how personality impacts people's experiences of their thoughts in terms of experienced happiness and worthwhileness. Over two weeks, 483 participants completed over 20,000 experience sampling questionnaires, including reports of hedonic and eudemonic well-being, and type and content of thoughts. Using multi-level modelling we show that personality traits recorded prior to the start of the study for all participants interact with thought variables to significantly predict experiences of worthwhileness. Openness to experience was the personality trait with the greatest impact on how content and type of thoughts affected worthwhileness. Predictions of happiness were not significantly improved by the addition of interactions between personality and thoughts. Implications for the broader literature on the relationship between personality and well-being are discussed.

Introduction

The idea that what we think about is intricately tied to how we feel is not a new one. In fact, it is an intuition that can be traced back several millennia. Yet, despite the keen interest of philosophers, thinkers and, more recently, scientists in the relationship between happiness and thoughts, surprisingly little is known about the role that individual differences play in this relationship. In other words, do different people benefit more from (or suffer more under) different kinds of thoughts? While there is some research focusing on clinical populations (Cuijpers et al., 2013; Sin & Lyubomirsky, 2009), less is known about how non-clinical traits in the general population affect people's experiences of thoughts. With well-being interventions becoming increasingly popular over the past decade (e.g., Bolier et al., 2013; Buruck et al., 2016; Guest, 2017), answering this question would enable more personalised approaches for managing thoughts and improving well-being. It may also inform the development of the myriads of easily available self-help tools that are currently being developed without the support of robust empirical evidence (Bakker et al., 2016).

Previous research has already shown that personality acts as a moderator in the relationship between external factors and well-being (Anusic et al., 2014; Boyce et al., 2016;

Soto & Luhmann, 2013) and predicts a wide range of preferences and behaviours (e.g., Booth-Kewley & Vickers, 1994; Delaney et al., 2013; Ferguson et al., 2016), suggesting that this may apply to thoughts as well. We explore the relationship between thoughts and two elements of well-being, namely, hedonic well-being (happiness) and eudemonic well-being (worthwhileness). Past research has shown these constructs to be highly correlated, but clearly distinct from one another, as there is plenty of evidence that people have experiences of low happiness and high worthwhileness, and vice versa (Baumeister et al., 2013; Choi et al., 2017; Dwyer et al., 2017; White & Dolan, 2009). However, no previous research has explored differences between the hedonic and eudemonic experiences of thoughts.

Of particular interest when it comes to thoughts is the phenomenon that researchers have broadly defined as mind-wandering, whereby people's attention drifts away from the activity, task or experience that they are engaged in (Smallwood & Schooler, 2015). We know from previous literature that such thoughts are prominent across the population, with researchers finding that mind-wandering makes up between 40% and half of our waking thoughts (Killingsworth & Gilbert, 2010; Klinger & Cox, 1987). Over the past decade, researchers in the field have come up with a range of different labels and sub-categories of mind-wandering to capture the nuances in methods and measures with which these thoughts are recorded (Callard et al., 2013; Engert et al., 2014; Smallwood, 2013; Watkins, 2008). Here, we focus specifically on thoughts that people report to be unrelated to the current activity that they are engaged in. While the literature does not have an existing label for such thoughts, we estimate that they are closest to what the experimental literature defines as task-unrelated thoughts (TUT; Seli et al., 2018; Smallwood & Schooler, 2006, 2015).

While we may expect the interaction between individual characteristics, thoughts and well-being to be relatively complex, previous research has brought ample evidence on the pair-wise links. Individual-specific characteristics, and personality in particular, explain large amounts of variation in well-being reports – between 30 and 50% (Diener & Lucas, 1999; Lyubomirsky et al., 2005). Specifically, neuroticism and extroversion appear to be strong, consistent predictors of a wide range of well-being measures, while conscientiousness also shows consistent relationships with well-being (Anglim et al., 2020; Hayes & Joseph, 2003; Lucas, 2018).

Furthermore, personality is related to the thoughts people report (Carciofo & Jiang, 2021; Kane et al., 2017; Robison et al., 2017, 2020). Higher neuroticism and lower

consciousness predict higher frequencies of mind-wandering reports (Mason et al., 2013; Perkins et al., 2015; Carciofo et al., 2016), while openness to experience relates to default network activity in the brain, which is also associated with mind-wandering (Beaty et al., 2016). Personality has also been linked to valence of thoughts (Kercher et al., 2009; Neff et al., 2007), while the relationship between content of thoughts and personality has yet to be explored in more depth.

The research on the relationship between thoughts and well-being has confirmed that how we feel is related to various dimensions of our thoughts. Although much of this research has focused on ruminations or specific forms of recurring thoughts (Harrington & Loffredo, 2010; Joormann, 2010; Newman & Nezlek, 2019), it has been demonstrated that what we think about (content; see Andrews-Hanna et al., 2013; Nyklíček et al., 2021; Ruby et al., 2013; Smallwood & O'Connor, 2011; Smallwood & Schooler, 2015), whether or not it is related to the current activity (type; see Brose et al., 2011; Franklin et al., 2013; Killingsworth & Gilbert, 2010) and whether it is positive or negative (valence; see Blouin-Hudon & Zelenski, 2016; Marchetti et al., 2012; Poerio et al., 2013; Schooler et al., 2014; Smallwood & Andrews-Hanna, 2013; Welz et al., 2018) have consistent effects on well-being in the general population. Early research showed that TUT tend to be negatively associated with well-being, although more recent developments have suggested that it may not actually be the type of thought, but rather the content and the valence that are most predictive of well-being.

Wilson et al. (2019) showed that personality weakly predicted enjoyment derived from thinking, although the large majority of their individual-specific measures were not significantly related to their outcome variable. They find weak relationships between openness to experience, agreeableness and enjoyment from thinking. However, no single study directly looks at interactions between personality and thoughts relative to well-being. As such, it is still unclear whether there are individual differences in the long-established relationship between thoughts and well-being. In this study, we apply multi-level modelling to a longitudinal panel dataset of university students and staff to explore how the interaction between individual-specific characteristics (specifically, the Big 5 personality traits) and type, valence and content of thoughts affects people's reports of experienced happiness and worthwhileness.

We explore whether accounting for individual-specific differences in relation to thoughts better explains variation in experienced well-being than thoughts alone. We use multi-level models to (1) determine whether the relationship between thoughts and well-being is better explained by accounting for individual differences in general, and (2) whether self-reported personality traits are able to account for this individual-specific variation. In doing so, we hope to validate and deepen the present understanding of the relationships between (a) personality and thoughts, (b) thoughts and well-being, and (c) personality and well-being. A particular novelty of this work lies in considering different components of thoughts and of well-being as we analyse different types and contents of thoughts in relation to both eudemonic and hedonic well-being (i.e., happiness and worthwhileness).

The question of whether the link between thoughts and well-being is consistent across people with different personality traits is of paramount importance for the proper incorporation of the previous findings in the design of more personalised well-being enhancing interventions. We believe that this study will also serve as a call-to-arms for well-being researchers to explore new mechanisms and constructs that may underpin the impact of both personality and thoughts on well-being.

Methodology

Data collection

Data were collected by Koa Health (formerly Telefonica Alpha) using the Reflections app, with approval of LSE's Research Ethics Committee. The Reflections app is a custom-made mobile app available on iPhone and Android that requires participants in the study to fill in a set of individual-specific characteristics (ISC) questionnaires, after which they are asked to answer Ecological Momentary Assessment (EMA) questionnaires up to five times a day over the course of two weeks. The EMA questionnaires ask people about their activities, their company, their thoughts and their well-being (see also Shiffman et al., 2008). Participants are prompted by a notification at random times during separate two and a half hour windows throughout the day (between 9:00AM and 9:30PM local time). After receiving the prompt, they have a window of thirty minutes to open the questionnaire and answer it before it expires. The full ISC and EMA questionnaires are available in the supplementary materials (Appendix A1).

Participants

Participants were recruited among students and staff from the London School of Economics and Political Science (LSE) between January and February 2019. During this time, 816 participants filled in the onboarding questionnaires, which includes all ISC questionnaires (i.e., self-esteem, big 5, delayed gratification, optimism, sense of control and attitude towards uncertainty), as well as demographic and general well-being questions. Participants were considered to have completed the study if they managed to complete over 70% of the daily EMA questionnaires, and were paid £20 upon completion. Participants who did not manage to complete 70% of the questionnaires were paid £5 for partial completion of the study (partial completion required them to complete at least the onboarding survey).

In the present study, we use the data from all participants that provided complete answers to the personality questionnaire in the onboarding (i.e., only participants that answered every single item) and whose EMA entries included at least one report of thoughts alongside a happiness or worthwhileness report. Of the 816 participants that started in the study, 284 failed to fill in a single valid EMA questionnaire. Of the remaining 532 participants, 49 did not provide complete answers to the personality questionnaire, meaning that the final sample that is considered in this study is composed of 483 participants and 20,393 EMA entries. This sample is composed of 66.7% of female respondents and 81.5% of students. While we did not ask for the respondent's exact age, we know that 83.4% of them are under 30 and only 6.6% were older than 40.

The mean rate of completion of the EMA questionnaires was 60.3% (42.2 out of 70 possible). The median completion rate was 74.3% (52 out of 70). A total of 27,802 thoughts were reported across all entries, 11,804 of which were TUT (39.9%).

Of the 20,393 entries, 5,363 entries included reports of happiness but not worthwhileness, and 5,309 reports included reports of worthwhileness but not happiness, meaning that our final samples for momentary happiness and worthwhileness differ slightly in size. Specifically, the sample used to analyse momentary happiness is composed of 479 individuals and 15,030 observations, and the sample used to analyse momentary worthwhileness of 477 individuals and 15,084 observations. In these respective samples, the mean happiness is 6.37 (SD=1.93) and the mean worthwhileness is 6.39 (SD=2.18).

Measures and coding

Well-being. We focus on momentary reports of hedonic and eudemonic well-being, as suggested by Dolan and colleagues (Dolan, 2014; Dolan & Kudrna, 2016; Dolan & Metcalfe, 2012). Momentary happiness and worthwhileness were measured using the following questions: *'How happy did you feel?'* and *'How worthwhile did this feel?'*. Both questions were answered on a scale of 0 to 10, and resulting variables were treated as continuous. Entry-level reports of well-being were standardized (mean = 0, SD = 1) to facilitate interpretability of coefficients resulting from interaction models.

Personality. Personality traits were captured according to the big 5 classification using a set of fifty items that participants rated on a scale of 1 to 5 with 10 items for each trait, resulting in each trait being scored on a scale of 10 to 50. Questions and scale were taken from the IPIP, as this instrument showed a good balance between low number of items and high level of internal consistency in previous studies (Goldberg, 1999; Gow et al., 2005). No changes were applied to the scores resulting from the traits of agreeableness (Cronbach's $\alpha = 0.83$), extroversion ($\alpha = 0.89$), conscientiousness ($\alpha = 0.77$) and openness to experience ($\alpha = 0.81$). Neuroticism was reverse scored in the data in order to reflect the idea that a higher score is associated with the more desirable trait. The resulting characteristic was labelled emotional stability ($\alpha = 0.89$) in the dataset. Like the well-being measures, all aggregated personality trait scores were standardized (mean = 0, SD = 1). As such, coefficients associated to personality traits and interactions with thought variables will be interpreted as the effect of a 1 SD increase in the relevant personality trait.

Thoughts. Thought variables concerning type, valence and content of thought were coded in binary format. The type of thought refers to whether the participant reported that they were thinking about their current activity or whether their mind was wandering. We label such a mind-wandering episode as "having a *task-unrelated thought*". This is captured by the variable labelled *TUT*. Content of thoughts was split according to a social and a temporal dimension. In the social dimension, variables were created to indicate when a thought was related to the self or to others. In the temporal dimension, variables were created for thoughts related to the past and the future. For both dimensions of content, we accounted for the possibility that the social or temporal content was not specified. We also recorded the valence of the thought, which was coded as positive, neutral or negative.

Statistical methodology

To address whether thoughts are predicted by personality traits, we use random effect logistic regressions to look at the effect of personality on each of the thought variables. Simple random effect models are used because personality traits only capture elements of between-person variation, making the chosen models more efficient than multi-level models that also capture within-person variation (see Bell et al., 2019). We run these models for all variables of type, social and temporal content of thoughts, and positive and negative valence. We interpret these coefficients using odds ratios. The regression equation looks as follows:

$$(1) \quad thought\_var_{ij} = OR_0 + OR_1 agr_j + OR_2 cons_j + OR_3 ext_j + OR_4 open_j + OR_5 stab_j + u_{0j} + e_{ij}$$

where *i* is the specific entry reported by the individual participant *j*. OR_0 is the constant term, *agr, cons, ext, open* and *stab* are the personality traits (respectively, agreeableness, conscientiousness, extroversion, openness to experience and emotional stability), *thought_var$_{ij}$* is the relevant thought variable, u_{0j} captures individual participant effects and e_{ij} is the entry-level residual error.

In these models, we look at (1) the Wald chi², which indicates whether personality traits in general predict the thought variables better than the null model, which would only include a constant and the error terms and (2) the coefficients of each personality trait in the form of odds ratios.

To discuss the main hypothesis of the study, which looks at the interactions between personality and thoughts, we use mixed-effects multilevel regressions (MLM), as these models look at both between- and within-person effects, as well as interactions between the two. Previous papers have already looked at whether Big 5 personality traits moderate individual reactions to major life events, such as marriage, childbirth or unemployment in terms of their well-being (Anusic et al., 2014; Boyce et al., 2016; Yap et al., 2012). While these papers did not use EMA data or look at internal determinants of well-being, we employ similar models to account for the two-level longitudinal structure of the data.

We construct our model step-by-step, using the effect of the type of thoughts on momentary well-being as a starting point. We estimate each model using random intercepts first, followed by the inclusion of random slopes for each thought variable. If the random slopes model is a significant improvement on the model without slopes (as determined by the

likelihood ratio), random slopes are then preserved in every subsequent model. Personality variables are included in the models using random slopes. Interactions between personality variables and thought variables, as well as the relative fit of each model, are discussed. The regression equations for all models are shown below:

$$(2) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + u_{0j} + e_{ij}$$

$$(3) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + u_{0j} + u_{1j} TUT_{ij} + e_{ij}$$

$$(4) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + \beta_{2-4} thought\_content_{ij} + u_{0j} + u_{1j} TUT_{ij} + e_{ij}$$

$$(5) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + \beta_{2-4} thought\_content_{ij} + u_{0j} + u_{1j} TUT_{ij} + u_{2-4j} thought\_content_{ij} + e_{ij}$$

where u_{1j} represents the random slope associated with the variable TUT_{ij}, such that the full effect of this variable for every individual participant j is $\beta_{1j} = \beta_1 + u_{1j}$.

$$(4) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + \beta_{2-4} thought\_content_{ij} + \\ \beta_{5-9} personality\_traits_j + u_{0j} + u_{1j} TUT_{ij} + e_{ij}$$

$$(5) \qquad WB_{ij} = \beta_0 + \beta_1 TUT_{ij} + \beta_{2-4} thought\_content_{ij} + \\ \beta_{5-9} personality\_traits_j + \beta_{10-14} TUT_{ij} * personality\_traits_j + \\ \beta_{15-34} thought\_content_{ij} * personality\_traits_j + u_{0j} + u_{1j} TUT_{ij} + e_{ij}$$

The models also included the variables of valence of thoughts, which were removed from the equations above for brevity. In the event that including a random slope causes the model to fail to converge, we identify which variables cause this failure to converge and remove them from the list of random slopes. These variables are preserved in the model as control variables, for consistency with earlier models, but are not interacted with personality traits, as there is no evidence of individual differences in how they relate to well-being.

In the results and discussion sections that follow, we first assess whether models with interactions are significantly better at estimating well-being than the models without interactions. For this, we use likelihood ratio tests to see if the marginal improvement from one model to the next is significant. Following this, we discuss coefficients and associated significance levels after applying a False Discovery Rate Controlling Procedure (see Benjamini & Hochberg, 1995; Glickman et al., 2014) to correct for multiple hypothesis testing.

In addition, we run the same set of models for other individual-specific characteristics, including self-esteem, optimism, attitude towards uncertainty and sense of control. These additional models can be found in the supplementary materials (Appendix A3). All statistical tests were performed using STATA (SE 17.0).

Results

Effect of personality on thoughts

Not all variables of thoughts are significantly predicted by personality. As indicated by the Wald chi-squared statistics, the model predicting the type of thought that people report is not significant ($\chi^2(5) = 6.72$, p = 0.242). As such, personality cannot be said to directly impact people's probability of reporting TUT. The same holds for thoughts about others ($\chi^2(5) = 6.59$, p = 0.253) and thoughts about the past ($\chi^2(5) = 10.10$, p = 0.072). Models for other dimensions of content (i.e., self- and future-related) are significant at p < 0.010. Table 9 below shows the results for the random effect logistic regressions with every thought variable as a dependent variable. Coefficients are reported as odds ratios. Only results of significant models are discussed in text.

Content of thoughts. We find that a 1 standard deviation (SD) increase in emotional stability is associated with a decreased probability of reporting a thought about the self (OR = 0.799, p = 0.002) or about the future (OR = 0.872, p = 0.035). Conversely, a 1 SD increase in openness is associated with a higher probability of reporting a thought related to the self (OR = 1.223, p = 0.007) or to the future (OR = 1.247, p = 0.001). Neither agreeableness, conscientiousness nor extroversion are significantly associated with the probability of reporting any of these contents of thoughts.

Valence. We find that valence of thoughts is the component of thoughts that is most strongly predicted by personality traits (p < 0.001). The personality trait that appears to be most predictive of valence is emotional stability. A 1 SD increase in emotional stability is associated with a decreased probability of reporting a negative thought (OR = 0.614, p < 0.001) and with an increased probability of reporting a positive thought (OR = 1.290, p < 0.001). Furthermore, conscientiousness appears to be a significant predictor of the probability of reporting a negative (OR = 0.871, p = 0.022) or a positive thought (OR = 1.189, p = 0.003), and higher extroversion is associated with a higher probability of reporting a positive thought (OR = 1.238, p < 0.001).

Thoughts	Type	Valence		Content (social)		Content (temporal)	
Personality	TUT	Negative	Positive	Self	Others	Past	Future
Agr	1.064	1.023	1.053	1.105	1.058	1.018	1.060
	(0.071)	(0.062)	(0.062)	(0.079)	(0.099)	(0.073)	(0.070)
Cons	0.967	0.871*	1.189**	1.078	0.944	0.987	1.046
	(0.064)	(0.053)	(0.070)	(0.077)	(0.089)	(0.071)	(0.069)
Ext	1.007	0.982	1.238***	0.944	1.120	1.076	0.969
	(0.070)	(0.062)	(0.076)	(0.070)	(0.108)	(0.080)	(0.066)
Open	1.139	1.123	1.098	1.223**	1.159	1.161*	1.247**
	(0.079)	(0.071)	(0.067)	(0.091)	(0.113)	(0.088)	(0.086)
Stab	0.929	0.614***	1.290***	0.799**	0.977	0.859*	0.872*
	(0.061)	(0.038)	(0.075)	(0.057)	(0.090)	(0.062)	(0.057)
Intercept	0.623***	0.106**	0.188***	0.099***	0.056***	0.058***	0.156***
	(0.039)	(0.006)	(0.077)	(0.007)	(0.005)	(0.004)	(0.010)
N	20393	20393	20393	20393	20392	20393	20393
Individuals	483	483	483	483	483	483	483
Wald χ^2 (5)	6.72	80.19	78.35	20.9	6.59	10.10	17.38
P	0.242	0.000	0.000	0.001	0.253	0.072	0.004

Table 9: Random effect logistic regression results with variables of type, valence and content of thoughts as dependent variables (DV) and personality traits as independent variables (IV). Coefficients are reported in odds ratios to improve interpretability. All personality variables are standardised (mean = 0, SD = 1). *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Multi-level analysis

Direct relationship with thoughts. Early models including only thoughts and personality reflect findings from the previous literature. Indeed, prior to including random slopes for thought variables (i.e., prior to accounting for between-subject variance in the effect of thought variables on well-being), we see that TUT are not significantly related to happiness ($p = 0.347$). Only thoughts related to others ($p = 0.037$) and valence of thoughts ($p < 0.001$) appear to significantly predict happiness. Furthermore, TUT significantly predict worthwhileness ($p = 0.013$), as well as valence of thoughts ($p < 0.001$) while no content variables do. Only valence of thoughts remains a significant predictor after correcting for multiple hypotheses testing. Tables for these models can be found in the supplementary materials (Appendix A3).

Including random slopes in these models suggests that accounting for individual-specific differences in the way people experience type and content of thoughts better explains momentary well-being than when we treat the relationship between thought variables and well-being as identical across individuals. In these random slope models, we find no significant relationships between well-being and type or content of thoughts, except for TUT significantly predicting worthwhileness ($p = 0.027$, before multiple hypotheses testing).

Direct relationship with personality. In accordance with the literature, the personality traits that significantly predict well-being are conscientiousness (p = 0.007 for happiness, p < 0.001 for worthwhileness), extroversion (p = 0.050, p = 0.001) and emotional stability (p < 0.001, p < 0.001). Agreeableness (p = 0.105, p = 0.185) and openness to experience (p = 0.425, p = 0.980) do not significantly predict well-being.

Interactions between thoughts and personality (happiness). We find that the model including interactions does not explain momentary happiness better than the model without interactions (χ^2(25) = 28.796, p = 0.273). This is confirmed by the AIC (31,121.11 for model without interactions vs 31,142.31 for model with interactions) and BIC (31,387.73 vs 31,599.38). From this, we conclude that the relationship between thoughts and happiness does not vary according to people's Big 5 personality traits, suggesting that other individual-specific characteristics may play a more important role in determining how people experience their thoughts in terms of momentary happiness.

Interactions between thoughts and personality (worthwhileness). Unlike momentary happiness, we find that worthwhileness is significantly better predicted by the model that includes interactions between personality and thoughts (χ^2(25) = 42.892, p = 0.014). Notably, the AIC (33,549.65 vs 33,556.76) and the BIC (33,816.40 vs 34,014.04) still favour the model without interactions. Nonetheless, we report the findings from the interaction model below. Regression results including significant interactions are presented in table 10.

Worthwhileness	(1)			(2)		
	Coef.	SE	P-value	Coef.	SE	P-value
TUT	-0.061	0.028	0.027	-0.062	0.027	0.023
Social						
Self	0.053	0.032	0.103	0.050	0.032	0.120
Others	0.006	0.030	0.846	0.011	0.028	0.703
Temporal						
Past	-0.002	0.033	0.960	0.004	0.033	0.910
Future	-0.017	0.029	0.573	-0.011	0.029	0.700
Valence						
Negative	-0.365	0.020	0.000*	-0.366	0.020	0.000*
Positive	0.404	0.014	0.000*	0.403	0.014	0.000*
Agreeableness	0.035	0.027	0.185	0.046	0.028	0.099
Conscientiousness	0.092	0.026	0.000*	0.104	0.027	0.000*
Extroversion	0.090	0.028	0.001*	0.091	0.029	0.002*
Openness	-0.001	0.027	0.980	0.004	0.028	0.881

Stability	0.115	0.026	0.000*	0.109	0.027	0.000*
Interactions						
Open*TUT				-0.078	0.030	0.009*
Open*Others				0.140	0.031	0.000*
Agr*Others				-0.078	0.029	0.008*
Intercept	-0.148	0.028	0.000	-0.149	0.028	0.000*
Random effects						
User						
TUT	0.103	0.020		0.098	0.019	
Self	0.091	0.025		0.087	0.024	
Others	0.067	0.022		0.047	0.018	
Past	0.098	0.027		0.091	0.026	
Future	0.053	0.018		0.051	0.018	
Intercept	0.284	0.021		0.285	0.021	
Residual	0.476	0.006		0.476	0.006	
Number of obs			15084			15084
Number of groups			477			477
Log likelihood			-16739.825			-16718.379

*Table 10: Mixed effect multi-level regressions on worthwhileness (DV) including (1) thought and personality variables with random slopes for thought variables (except "Present"), and (2) significant interactions between thought and personality variables. DV and personality variables are standardised (mean = 0, SD = 1). *: Coefficients significant after False Discovery Rate Controlling Procedure.*

We find several interactions between thoughts and personality that are significant even after controlling for multiple hypotheses testing. Specifically, we find that openness to experience moderates the relationship between TUT and worthwhileness. People who report higher levels of openness before the start of the study report lower levels of worthwhileness alongside TUT (β = -0.078, p = 0.009). Openness also moderates the relationship between thoughts related to others and worthwhileness, where people with higher openness seem to experience higher worthwhileness alongside thoughts related to others (β = 0.140, p < 0.001). Finally, the relationship between thoughts related to others and worthwhileness is also moderated by agreeableness. In this case, it seems that more agreeable people experience significantly lower worthwhileness alongside thoughts related to others (β = -0.078, p = 0.008).

We find no evidence that extroversion, conscientiousness or emotional stability moderated the relationship between thoughts and worthwhileness. As such, even though the model including interactions between thoughts and personality better predicts reported worthwhileness, it does not conclusively show that the Big 5 personality traits consistently drive the relationship between thoughts and worthwhileness.

Discussion

A great deal of the literature has shown the importance of thoughts on people's experiences of well-being (Andrews-Hanna et al., 2013; Killingsworth & Gilbert, 2010; Mason et al., 2013). However, whether and how an individual's reactions to such internal processes differ depending on personal characteristics remains unknown to date. This paper presents evidence that the relationship between thoughts and experiences of well-being is specific to each individual, and that some of these differences can be explained by personality, especially when it comes to experienced worthwhileness.

We find that the type of thought predicts neither happiness nor worthwhileness when we account for individual differences. This suggests that TUT are not *per se* negatively related to well-being. In other words, people are not systematically worse off when their attention is not on their current activity. This sharply contrasts findings in the past literature, which suggested that TUT have an outright negative effect on well-being (Killingsworth & Gilbert, 2010; Schooler et al., 2014).

Models attempting to explain this individual-specific variation using personality traits did not all show meaningfully significant results, as we find that interactions between thought variables and personality do not predict reports of happiness better than the model without these interactions does. The model predicting worthwhileness using interactions between personality and the remaining thought variables was a significant improvement over the model that did not include these interactions, however, three of the five personality traits (i.e., extroversion, conscientiousness and emotional stability) did not significantly moderate the relationship between any thought variable and well-being.

After applying a False Discovery Rate correction for multiple hypotheses testing, we find that the main personality trait that can be said to moderate this relationship is openness to experience. Indeed, we find that openness to experience moderates both the relationship between TUT and worthwhileness, and between thoughts related to others and worthwhileness. Specifically, the model shows that more open people tend to experience

lower worthwhileness when they report TUT, but higher worthwhileness when they report thoughts related to others. While these findings alone are not sufficient to draw robust conclusions regarding the mechanism underpinning how openness to experience affects how people perceive their thoughts, they complement a large body of existing evidence that finds positive correlations between openness of experience and various aspects of people's experience of TUT (e.g., Beaty et al., 2016; DeYoung, 2015), including the practice of mindfulness (Baer et al., 2006; Giluk, 2009; Hanley, 2016). As such, openness seems to be a personality trait that is important to the regulation and experience of where people focus their attention.

Openness to experience is broadly known to capture attentiveness to both internal and external stimuli, and has been linked to a range of cognitive processes (Connelly et al., 2014; DeYoung, 2015). As such, while the direct correlations between openness and well-being tend to be small and insignificant, it is plausible that it would play an important role in how people experience their thoughts. If people high in openness are more attuned to their internal experiences than people low in openness, this may lead them to be more strongly aware of, and therefore impacted by, the type and content of their thoughts. This idea is supported by recent research showing that people higher in openness tend to be more aware of their mind wandering than people low in openness (Ibaceta & Madrid, 2021). In the context of worthwhileness, this may suggest that highly open people are better at estimating how being distracted compares to focusing on the current activity, leading them to report lower worthwhileness scores when they experience TUT during activities that they would rather (or feel like they should) focus on. The same mechanism might explain why thoughts related to others are associated with higher levels of worthwhileness for people high in openness. It could be that such people find it inherently more rewarding to have thoughts related to others, as opposed to self-related thoughts, or thoughts whose social content is not specified.

Our results further show that openness to experience is one of just two personality traits that predicts the social and the temporal content of thoughts, alongside emotional stability, where openness to experience is associated with higher proportions of reports of self-, past- and future-related thoughts. This might indicate that people with higher openness to experience are able to report their thoughts with greater specificity, which would also be aligned with the view that they tend to be more aware of their internal experiences (see also, Ibaceta & Madrid, 2021). While the present findings do not allow us to draw definitive conclusions in this regard, it could be that a personality trait like openness to experience is

related to how vividly people experience their thoughts. Future research could explore this further by including either trait-like or momentary measures of vividness of TUT (e.g., Mar et al., 2012) and looking at whether these measures are predicted by openness or other personality traits.

We also find that more agreeable people tend to report lower worthwhileness when they report thinking about other people. This is an interesting finding, since agreeableness tends to capture how people interact with others, where more agreeableness is associated with avoiding interpersonal conflict. One explanation for this could be that more agreeable people tend to compromise more, meaning that their thoughts, when relating to others, might focus more on what they lost in the compromise than less agreeable people. Interestingly, Wilson et al. (2019) also highlighted openness to experience and agreeableness as two of the individual-specific characteristics that might moderate the relationship between being alone with one's thoughts and one's mood.

In general, including random slopes for all thought variables reveals that the relationship between TUT, their content and well-being indeed varies due to unobserved individual-specific characteristics, suggesting that the relationship between thoughts and reported happiness and worthwhileness is specific to each individual. In other words: no type or content of thoughts can definitively be said to be good or bad irrespective of who someone is. While this is altogether unsurprising, it has important implications for mindfulness or other thought-related interventions, particularly in light of recent evidence suggesting that such interventions may not be as ubiquitously beneficial for everybody as previous literature suggested (Kaufmann et al., 2021; Van Dam et al., 2018). Indeed, different types of interventions may be better suited to people with different individual-specific characteristics. Openness to experience could be one easily measurable characteristic that may then play a role in how people experience such interventions, depending on what kind of thoughts the intervention encourages (see also, Wilson et al., 2019).

That being said, the present study raises more questions than it answers when it comes to the role of individual-specific characteristics in how people experience their thoughts. While we can confidently say that individual differences in internal experiences exist and must be explored in more depth, the current state of the literature simply does not allow intervention designers to rely on psychometric scales and questionnaires to personalise their well-being interventions. One important step in this direction would be to understand what

kind of individual-specific characteristics actually drives this relationship. In the present paper, we focused on self-reported personality scales, and while such scales are intended to capture a broad range of behavioural and psychological characteristics, they tend not to focus so much on cognitive traits, like working memory capacity (Wilhelm et al., 2013) and attention control (Reinholdt-Dunne et al., 2013), which are consistent, strong predictors of mind-wandering (see, Banks & Welhaf, 2022; Welhaf et al., 2020). Exploring these traits and their impact on the relationship between thoughts and well-being could be all the more beneficial given that both working memory capacity and attention control can be trained (e.g., Hotton et al., 2018; Tang & Posner, 2009), which might create opportunities for personalised interventions that try to improve how people feel in relation to their thoughts through the individual characteristics that moderate this relationship.

The individual-specificity of the relationship between thoughts and well-being also raises the question of how to systematically quantify thoughts and their content in a way that accurately captures their incredible diversity. Indeed, while we have limited ourselves here to the social and the temporal dimension of thoughts in terms of exploring their content, the individual differences in how people react to their thoughts could also be driven by the fact that thinking "about others", or "about the past", for example, likely means very different things depending on the person who is reporting the thought. While part of this difference will be captured by the same individual-specific characteristics as we have mentioned above, the remainder is likely to depend on a broader socio-demographic and historical context. In other words, how you think about others depends not just on who you are, but also on who these others are, and how you think about the past depends on the things that have happened in and around your life.

To capture these nuances in the content of people's thoughts, a mere assessment of their individual-specific characteristics may not be enough. Instead, it may require a more qualitative or, at least, more granular approach to the way researchers approach the content of people's thoughts. This could take the form of EMA-like qualitative diary prompts, where people would be asked to describe their thoughts more lengthily than using sets of predefined options (e.g., Unsworth & McMillan, 2017; Unsworth et al., 2012). Such research could explore not only how the language used in these descriptions of thoughts relate to reports of well-being, but also whether the unobserved individual-specific characteristics that we find in the present study also predict patterns in the description of these thoughts.

The relationship between valence of thoughts and well-being is easier to establish, as positive thoughts have consistently been shown to have a positive impact on well-being, and vice versa. The failure of our models to converge when including random slopes for variables of valence of thoughts may suggest that the relationship between positive or negative thoughts and well-being is therefore less dependent on individual-specific characteristics, indicating that focusing on the promotion of positive thoughts and the reduction of negative thoughts may therefore be better-suited to interventions that require a one-size-fits-all approach.

We also note that personality better explains valence of thoughts than it explains type and content of thoughts, and that the personality traits that significantly predict the valence of thoughts are the same as those that significantly predict both happiness and worthwhileness (i.e., emotional stability, conscientiousness and extroversion). Further research may therefore be mindful of how valence of thoughts is discussed alongside other variables of thoughts. This is particularly relevant in the context of research that combines measures of valence with other components of thoughts, as past research has often selectively associated valence with some elements of type or content, but not others (e.g., discussing positive, neutral or negative TUT, but making no distinction between positive, neutral or negative thoughts related to the current activity; Killingsworth & Gilbert, 2010).

Limitations and concluding remarks

Our study is limited by several factors. Firstly, data were collected using a convenience sample of university students and staff. Our sample is therefore not representative of the general population, and findings may therefore not be generalisable. With the LSE welcoming a large proportion of international students, it is likely that our sample was much more culturally diverse than the average population in the UK. This may have come with both advantages and disadvantages. Indeed, while a culturally diverse sample would normally be desirable, our lack of cultural variables means that the effect of cultural background could not be disentangled from other individual-specific effects. It is therefore possible that research focusing on more homogenous samples would find stronger or more straightforward interactions between personality and thought variables. Given the inability of our happiness models to explain where individual differences in experience come from, we suggest that future research control for cultural variables on top of scale-based individual-specific characteristics.

In addition, we are limited by the potential non-randomness of our missing data. Indeed, participants may have self-selected into dropping out of the study at any point along the way or may have non-randomly missed certain notifications depending on what activity they were engaged in or who they were with. While we find no differences between participants that dropped out along the way and participants who stayed in the study when looking at the individual-specific characteristics that they reported, we cannot completely rule out the possibility that unmeasured characteristics caused attrition or missing data.

Finally, we are limited by the fact that we did not ask participants to complete the individual-specific characteristics questionnaires at the end of the study, on top of asking them before the start. Indeed, while the individual-specific characteristics that we discussed tend to be relatively stable overtime, there is also evidence to suggest that personality measures can be affected by contextual factors, and that the resulting changes are associated with changes in well-being (e.g., Boyce et al., 2017; Luhmann et al., 2014). While it is unlikely that we would have observed systematic changes in personality across our sample during the two-week period of the study, the inclusion of a post-study personality assessment might have provided a useful control and robustness check for our findings.

These limitations notwithstanding, our findings have broader implications for our understanding of the relationship between personality and well-being, which explains nearly half of the well-being variance in the three-factor model (Lyubomirsky et al., 2005). Specifically, our findings imply that all personality traits may affect how we feel, either through direct or indirect pathways. Whereas previous studies had shown effects of emotional stability, extroversion, conscientiousness and sometimes agreeableness on well-being, the consensus in the literature is that openness to experience is the personality trait that is least predictive of well-being measures (Anglim et al., 2020; Hayes & Joseph, 2003; Lucas, 2018). In showing that openness may contribute to experiences of eudemonic well-being through the way people experience their thoughts, we suggest that openness may in fact influence how we feel as well. Although the importance of this association as well as other personality–thoughts–well-being pathways need to be explored in more depth, the present study highlights a new mechanism through which both personality and thoughts may play an important role in determining well-being.

Nevertheless, our measures of personality were unable to explain the differences in people's experiences of thoughts in terms of happiness, meaning that these individual-

specific differences remain unobserved. This may suggest that the experience of thoughts is driven by more complex patterns or combinations of individual-specific characteristics. As such, certain combinations of personality traits or other characteristics may be better able to predict how people's thoughts relate to their well-being. Namely, cognitive traits like working memory capacity and attention control may prove to be more important moderators of the relationship between thoughts and well-being than the self-reported traits that were collected as part of this study. In addition, our findings encourage further work on exploring whether other individual differences, like cultural or socio-economic background (see Martinon et al., 2019), can better explain these variations.

Further exploration of individual-specific differences in thought experiences may also try to distinguish between different sets of thought components. For example, the intentionality of thoughts (i.e., whether TUT are intentional or not) may play an important role in moderating our present findings (see work by Seli et al., 2016a, 2016b, 2019). Similarly, the coding of content of thoughts could be expanded to incorporate more dimensions or categories.

All in all, our findings confirm that, when it comes to how thoughts relate to how we feel, a "one-size-fits-all" approach simply does not tell the whole story. It follows that designers of self-help tools, particularly in the realm of mobile apps that provide services like cognitive restructuring and other cognitive behavioural therapy practices, should be mindful of individual differences in the way people experience their thoughts (see also Bakker et al., 2016). At present, most of these self-help tools lack the necessary empirical frameworks to support their design and may therefore be unable to provide the general population with personally relevant interventions. The present paper highlights the importance of establishing such frameworks through analogous research.

Chapter 5:

In good company: the relationship between mind wandering and well-being depends on what you do and who you are with

Abstract

In the past decade, research has established that a relationship exists between mind wandering and well-being. We now know that besides whether the mind wanders or not, valence and content of thoughts also matter, but there is little evidence of how variations in our day-to-day context affect the relationship between thoughts and well-being. In this study, we look at the frequency of reports of mind wandering, specifically, task-unrelated thoughts (TUT), their valence and their content, as well as how they relate to measures of experienced happiness and worthwhileness, across 7 activities and 6 types of company that were most commonly reported by participants (N = 531) in a two-week experience sampling study. We find that the proportions of reported TUT, positive and negative thoughts vary greatly depending on context, and that there are substantial differences in how people's thoughts predict their well-being depending on what they are doing and who they are with. TUT are not significantly associated with happiness in general, but predict higher reports of happiness when people are with their partners. In addition, they negatively predict worthwhileness when people are studying, but not in any other activity. Additional context-dependent variations in the experience of content of thoughts are discussed.

Introduction

> *"I think and think and think, I've thought myself out*
> *of happiness one million times, but never once into it."*
>
> *– Jonathan Safran Foer*

According to a recent study, we think around 6,000 thoughts a day (Tseng & Poppenk, 2020). That is roughly one thought every 10 seconds of our waking time. Yet, there is still much we do not know about how, and in what contexts, our thoughts are associated with how we feel. In recent decades, social scientists have looked to quantitatively capture the relationship between what people think and various aspects of how they feel and behave (Brosowsky et al., 2021; Mooneyham & Schooler, 2013; Smallwood & Schooler, 2015).

However, little work has been devoted to how the context in which thoughts are reported drives this relationship, particularly in ecologically valid settings. Specifically, how does what you do (activities) or who you are with (company) influence what you think about in day-to-day settings? And how do these contextual factors affect the relationship between your thoughts and how you feel?

Answering these questions is particularly important to understand the nuances of the relationship between our thoughts and our well-being. A useful starting point for this is Smallwood and Andrews-Hanna's (2013) context-regulation hypothesis, which stipulates that our experiences of thoughts ought to vary across contexts, particularly according to how demanding our activity or task is. However, available evidence at the time did not allow them to support their hypothesis with ecologically valid data, nor were they able to discuss specific activities or types of company. Therefore, it is still unclear to what extent our experiences of thoughts are homogenous across contexts, and there is a lack of studies reporting such contextual differences in day-to-day settings.

Understanding how people's thoughts affect how they feel depending on what they are doing or who they are with on a day-to-day basis could help inform both what they choose to think about in different contexts and what kind of activities or company they choose to engage in. This could complement existing research showing that different contexts are associated with vastly different experiences of hedonic and eudemonic well-being (Dolan, 2014; Grimm et al., 2015; White & Dolan, 2009). To this end, the present paper looks at the relationship between self-reported thoughts and hedonic and eudemonic well-being (respectively, happiness and worthwhileness) across a range of activities and types of company, using a longitudinal experience sampling (or Ecological Momentary Assessment, EMA; Shiffman et al., 2008; see also, Larson & Csikszentmihalyi, 1983) dataset.

Previous literature has already looked at the general relationship between thoughts and well-being. As such, there is a vast body of evidence that distinguishes between when people's thoughts are directed towards their current activity and when their mind is wandering or off-task (Callard et al., 2013; Engert et al., 2014). While the majority of the literature has embraced the term "mind wandering", recent papers have pointed out ambiguities in the way researchers define and measure such thoughts (Irving & Glasser, 2020; Murray et al., 2020; Seli et al., 2018a). In the present paper, we focus on thoughts that occur when attention is directed away from the current activity. In experimental settings, such

thoughts have been broadly defined as task-unrelated thoughts (Seli et al., 2015, 2018a), which is the terminology that will be used throughout this paper.

While researchers generally find a negative relationship between task-unrelated thoughts (TUT) and well-being (Brose et al., 2011; Franklin et al., 2013; Killingsworth & Gilbert, 2010), recent research has shown that TUT are highly context dependent (Hobbiss et al., 2019; Rummel et al., 2020; Seli et al., 2018b), suggesting that their relationship to well-being might be as well (Mills et al., 2021). Indeed, much research in the past decade has focused on trying to understand what kinds of TUT have outrightly negative effects, and which ones can be positively related to well-being (e.g., Franklin et al., 2013; Poerio et al., 2013; Schooler et al., 2014). While negative TUT obviously have a negative relationship with well-being (Marchetti et al., 2012; Smallwood & Andrews-Hanna, 2013), positive TUT tend to positively predict well-being (Blouin-Hudon & Zelenski, 2016; Welz et al., 2018).

The content of our thoughts also matters for our well-being (Andrews-Hanna et al., 2013; Linz et al., 2019; Welz et al., 2018). Studies focusing on this relationship have considered many categories of content, most notably, temporal and social content of thoughts. Findings in this branch of research suggest that past-related thoughts are related negatively to well-being, while others-, as well as future- and self-related thoughts positively predict it (Oettingen, 2012; Poerio et al., 2013; 2015; Smallwood & O'Connor, 2011; Ruby et al., 2013).

Past literature has previously related processes like mind wandering and TUT to resource allocation theories, suggesting that people report more of such thoughts in low-attention-demanding tasks (e.g., Randall et al., 2014, 2019). It has further shown that people are able to regulate their levels of mind wandering depending on how much attention their task requires (Seli et al., 2018c). In addition, Smith et al. (2018) showed that the occurrence of TUT does fluctuate throughout the day, although they did not discuss whether this was related to the activities or the company that people were engaged in. These findings all align with Smallwood and Andrews-Hanna's (2013) context regulation hypothesis, and suggest that contextual differences in how frequently people report TUT should be found in day-to-day contexts as well. One may expect, for instance, that low-attention-demanding activities will be associated with higher proportions of TUT than high-attention-demanding activities. The past literature does not allow for inferences to be made regarding how TUT vary depending on company.

Furthermore, the effect of TUT on various performance indicators has been studied in the context of specific activities, such as studying (Kane et al., 2021; Risko et al., 2012; Szpunar et al., 2013), working (Dane, 2018), commuting (Yanko & Spalek, 2014; Baldwin et al., 2017), using social media (Oschinsky et al., 2019) or exercising (Balagué et al., 2015; Latinjak, 2018; Miś & Kowalczyk, 2020). Most of these studies make use of experiments, surveys, or simulated environments to isolate and analyse specific activities. However, none of these used EMA to study TUT in ecologically valid contexts or to compare occurrences of TUT and their content across different activities.

Recently, Nyklíček and colleagues (2021) explored the interactions between content and context of thoughts using EMA-like questionnaires. They asked their participants to report their activities following Killingsworth and Gilbert's (2010) classification, as well as the content of their thoughts. They then looked at whether interactions between thoughts and context predicted well-being, although they focused mostly on the distinction between active and passive, and positive, neutral and negative activities. Using these categories to group activities together, they find significant interactions between some contents and contexts, showing that context matters when it comes to how people experience their thoughts. However, as their categorisation of contexts was done *ad hoc* and without backing of any previous literature, it is unclear how their findings should be interpreted in the broader context of literature on the relationship between thoughts and well-being. As such, a comprehensive overview of how context affects TUT and their relationship with well-being is still missing. In addition, no such work exists looking at the association between TUT and well-being depending on who people are with, even though we know that who people spend time with is an important predictor of well-being (e.g., Quoidbach et al., 2019).

In the present paper, we consider the effect of TUT and content and valence of thoughts on measures of happiness and worthwhileness across the 7 activities and 6 indicators of company that are most prominently reported in a dataset of 21,721 EMA entries completed over the course of two weeks by 531 participants. While other large-scale studies have used EMA to discuss the general relationship between thoughts and well-being (Brose et al., 2011; Choi et al., 2017; Killingsworth & Gilbert, 2010; Nyklíček et al., 2021), or between activities, company and well-being (Csikszentmihalyi & Hunter, 2014), none have discussed the relationship between thoughts and well-being across different activities and types of company with the same sample of participants. Besides, no previous research has

reported differences in the frequency of TUT or thought valence and content reports across contexts.

As such, the objectives of the current paper are twofold: (1) to establish whether levels of TUT and content and valence of thoughts vary depending on the activity and company; and (2) to determine whether these thought-related variables predict reports of happiness and worthwhileness differently depending on the context.

Methodology

Data collection

Data were collected in partnership with Koa Health (previously Telefonica Alpha) using a mobile application called Reflections, with approval of LSE's Research Ethics Committee. The app, which was designed for the study and available on iPhone and Android, requires participants to answer daily EMA questionnaires, when notified. Participants received five notifications at random times during the day with an EMA questionnaire. After receiving the notification, they had a thirty-minute window to open it before it expired. This was to make sure that people were actually reporting the activity they were engaged in at the time of the notification, rather than the activity that they were engaged in when they happened to check their phone.

The EMA questionnaire asked people about their activities, their company, their thoughts and their well-being in the moment. The full EMA questionnaire is available in the supplementary materials (Appendix A1). Since the main aim of the original study was not to study thoughts in particular, the analysis presented here is exploratory in nature. Nonetheless, the data collection and main hypotheses of the larger study were preregistered on OSF (https://osf.io/yt745).

Participants

Participants were recruited among students and staff from the London School of Economics and Political Science (LSE) between January and February 2019. Students and staff were given two weeks to register for the study by downloading the app. The timeframe was determined to make sure that all data were collected during regular term time. To account for the exploratory nature of certain elements of the study, no other limit was set to the sample size.

By the end of the registration period, 816 participants had downloaded the app and filled in the onboarding questionnaire, including demographics, individual-specific

characteristics (e.g., personality, self-esteem, pleasure-purpose balance, etc) and general well-being. Participants who completed at least 70% of the daily questionnaires were paid £20 in the form of an Amazon voucher. Other participants who completed at least the onboarding questionnaire were paid £5 for partial completion.

Here, we consider all EMA entries of participants who completed at least one valid EMA entry. EMA entries are considered valid when they contain answers to all thought-, activity- and company-related questions, as well as one report of experienced happiness or worthwhileness. A discussion of resulting attrition and missing values can be found in the supplementary materials (see chapter 2 and general discussion).

Of the initial 816 participants, 531 provided at least one valid EMA. The final sample is composed of 81.0% of students (22 participants did not report their student status) and 65.3% of the participants were female (24 did not report their gender). While we did not ask for the participant's exact age, we know that 75.9% of participants are aged between 18 and 26, and less than 6.5% are older than 40 (21 did not report their age).

Across the 531 participants in our full sample, the mean completion rate of EMA is 58.5% (40.9 reports out of a possible 70) while the median completion rate is 72.9% (51 out of 70 reports), resulting in a full sample of 21,721 unique EMA entries. These entries include a total of 29,435 thought reports, of which 11,786 are TUT (40.0%), which is similar to previous studies on mind wandering (Klinger & Cox, 1987; Killingsworth & Gilbert, 2010).

Of the 21,721 entries, 5,770 entries do not include reports of experienced worthwhileness and 5,817 entries do not include reports of experienced happiness. 9 out of 531 participants failed to fill in at least one report of experienced worthwhileness, and 7 failed to fill in at least one report of experienced happiness. As a result, the sample used to analyse experienced happiness is composed of 524 individuals and 15,877 unique entries, and the sample used to analyse experienced worthwhileness of 522 individuals and 15,926 unique entries. In these respective samples, the mean experienced happiness is 6.34 ($SD = 1.93$) and the mean experienced worthwhileness is 6.35 ($SD = 2.18$).

Measures & Coding

The larger study included additional onboarding questionnaires, but as the main object of this paper is to compare reports of thoughts and well-being across activities and company in EMA entries, the variables of interest are all taken from these entries. Well-being measures were captured on a scale of 0 to 10, as experienced happiness (*'How happy did you feel?'*)

and worthwhileness (*'How worthwhile did this feel?'*; see Dolan & Metcalfe, 2012; Dolan & Kudrna, 2016).

Thoughts were coded first according to their type (i.e., whether a thought was related to the current activity, or whether it was a report of TUT) and their valence (positive, neutral, negative). As such, the variable capturing TUT indicates when a participant is "off-task" versus "on-task" while engaged in the activity that they report. Then, all thoughts that were classified as TUT were also coded according to their social and temporal content. Resulting variables are binary, indicating the absence or presence of a certain valence or content of thoughts in a given entry.

Construct	Variables	Scale	Description
Pleasure	*Happiness*	0-10	Answer to the question *'How happy did you feel?'*
Purpose	*Worthwhileness*	0-10	Answer to the question *'How worthwhile did this feel?'*
Type of thoughts	*Task-unrelated thoughts*	Binary	Equals 1 when any thought that is not *'Current activity'* is reported
Valence of thoughts	*Positive, negative, neutral*	Binary	Equals 1 when a thought of the relevant valence is reported
Content of thoughts	*Self, others*	Binary	Equals 1 when the relevant social content of thought is reported
	Past, future	Binary	Equals 1 when the relevant temporal content of thought is reported
Activity	24 dummy variables (e.g., *working, studying, eating, commuting*, etc.)	Binary	Equals 1 when the relevant activity is reported
Company	6 dummy variables (*alone, colleagues, family, friends, partner, strangers*)	Binary	Equals 1 when the relevant company is reported

Table 11: Breakdown of dependent and independent variables, including scale and description.

To report their thoughts, activity and company, participants could choose from a selection of pre-determined options that were based on a prior study of the same kind (see Henwood et al., 2022). They also had the option to provide their own answer if none of the pre-determined ones were adequate. All answers that were manually typed in by participants were recoded into existing categories, when appropriate, or labelled as "other" in the dataset. As such, 5,230 out of 30,370 reported activities were recoded, 747 out of 29,435 reported thoughts and 341 out of 25,086 reported company.

For activities, participants were given 11 pre-set options when answering the question *"What were you doing just now?"*. The 5,230 manually added activities were then coded to match the activities used by Killingsworth and Gilbert (2010), resulting in a final list of 24 activities, including 22 from the original study, and another two ("social media" and "studying") that were added based on the characteristics of the present sample. While the full list of activities can be found in supplementary materials (Appendix A4), only the 7 activities that were reported over 1,000 times in the EMA entries are discussed in the subsequent analysis. These activities were: "Studying", "Eating/drinking", "Working", "Commuting", "Socialising", "Watching TV" and "Social media". The same criterion of 1,000 EMA reports was used for company, which was therefore split into the 6 most recurring categories: "Alone", "Friends", "Colleagues", "Partner", "Family" and "Strangers".

Descriptive statistics

Table 12 below shows the descriptive statistics for the well-being and thought variables that were described previously. As valence of thoughts was asked regardless of whether people reported a TUT, summaries of positive and negative thoughts use the full sample. In contrast, the proportion of each content of TUT is shown in the sub-sample of entries that contained reports of TUT.

Variable	*Min*	*Max*	*N*	*Mean*	*SD*
Well-being					
Happiness	0	10	15,877	6.34	1.93
Worthwhileness	0	10	15,926	6.35	2.18
Thoughts					
TUT	0	1	21,721	0.38	0.49
Negative	0	1	21,721	0.14	0.34
Positive	0	1	21,721	0.56	0.50
TUT content					
Social: self	0	1	8,355	0.35	0.48
Social: others	0	1	8,355	0.28	0.45
Temporal: past	0	1	8,355	0.23	0.42
Temporal: future	0	1	8,355	0.45	0.50
Activities					
Studying	0	1	21,721	0.26	0.44
Eating/drinking	0	1	21,721	0.21	0.40
Working	0	1	21,721	0.14	0.34
Commuting	0	1	21,721	0.12	0.33
Socialising	0	1	21,721	0.11	0.32
Watching TV	0	1	21,721	0.09	0.29

Social media	0	1	21,721	0.08	0.28
Company					
Alone	0	1	21,721	0.55	0.50
Friends	0	1	21,721	0.23	0.42
Colleagues	0	1	21,721	0.14	0.35
Partner	0	1	21,721	0.08	0.28
Family	0	1	21,721	0.06	0.24
Strangers	0	1	21,721	0.06	0.24

Table 12: Descriptive statistics for well-being and thought variables, as well as the context variables of activities and company, including number of observations (N), mean and standard deviation (SD).

Table 12 also shows the frequency with which the most recurring activities were reported, as well as each type of company. Since participants were allowed to report more than one activity per entry, the sum of proportions of reports of all activities is allowed to exceed 1. Considering all 24 activities, a single activity was reported per entry 72.0% of the time. Two activities were reported simultaneously 17.7% of the time and three activities were reported 7.0% of the time. Four or more activities were reported 3.3% of the time. Similarly, for company, participants reported only one type of company 86.2% of the time, two types of company 12.1% of the time, and three or more 1.7% of the time. As a result, the majority of correlations between activities are small and negative.

The same holds for company, except for being alone, which was negatively correlated with the other types of company. There were a few larger correlations between activities and types of company. For example, socialising was positively correlated with being with friends (r=0.315) and negatively correlated with being alone (r=-0.261), while being with colleagues was positively correlated with working (r=0.456). Table 13 shows a heatmap of the correlations between activities and types of company.
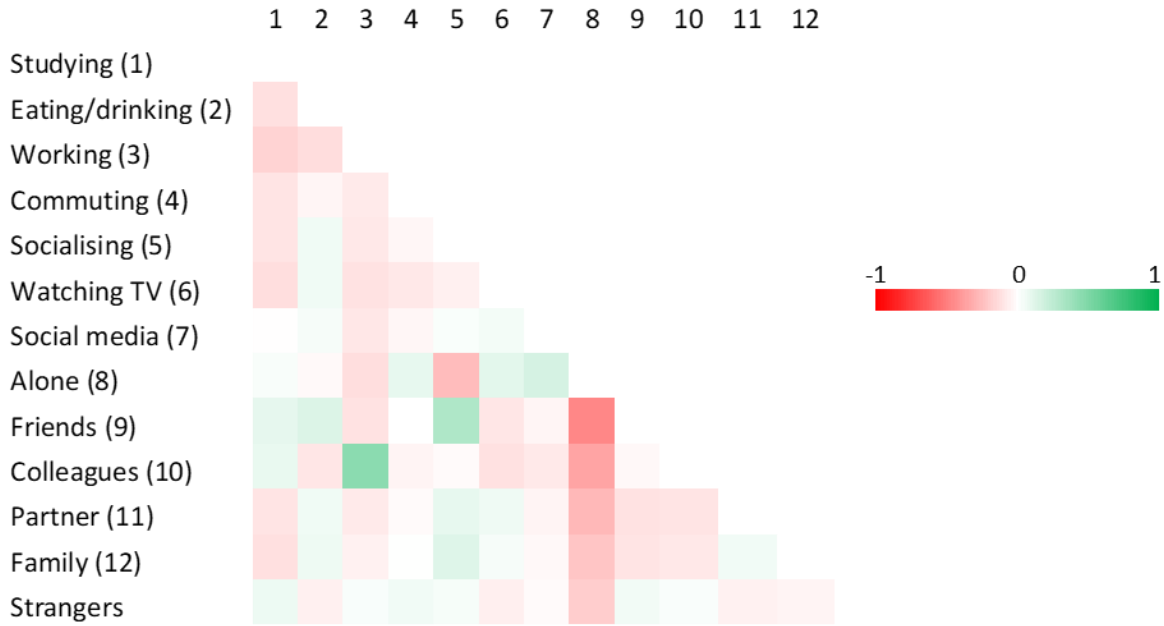
Table 13: Heatmap of correlations between activities and company. Darker shades of red and green indicate larger correlations (respectively, negative and positive).

Statistical methodology

To compare thought reports across activities, we use fixed effects linear probability models with TUT as the dependent variable, using the above-mentioned activities as independent variables. The model looks as follows:

$$TUT_{it} = \beta_1 studying_{it} + \beta_2 eating\_drinking_{it} + \beta_3 working_{it} + \beta_4 commuting_{it} + \beta_5 socialising_{it} + \beta_6 watching\_tv_{it} + \beta_7 social\_media_{it} + EE_i + e_{it}$$

, where EE_i captures the entity effects (or fixed effects) for each individual participant i, t denotes every unique entry for said participant and e_{it} is the error term. The same model using the 6 company variables as independent variables is applied. We subsequently run these models using variables of valence of thoughts as dependent variables. Standard errors are clustered at the level of individual i in all models.

Since specific content of thoughts was only reported when people reported TUT, these same models are applied to the content of thought variables, using the sub-sample of entries that include reports of TUT only.

To assess whether thoughts predict reports of happiness and worthwhileness differently across contextual variables, we use fixed effects regressions on sub-samples determined by activities and types of company. These models look as follows:

$$Well\_being_{it} = \beta_1 TUT_{it} + \beta_2 pos_{it} + \beta_3 neg_{it} + \beta_4 others_{it} + \beta_5 self_{it} + \beta_6 past_{it}$$
$$+ \beta_7 future_{it} + EE_i + e_{it}$$

, where EE_i captures the entity effects (or fixed effects) for each individual participant i, t denotes every unique entry for said participant and e_{it} is the error term, pos_{it} and neg_{it} are the variables indicating whether a thought as positive or negative, $others_{it}$ and $self_{it}$ refer to the social content of the thought and $past_{it}$ and $future_{it}$ to the temporal content of the thought.

Prior to running these models, variables of happiness and worthwhileness are standardised, such that they each have a mean of 0 and a standard deviation (SD) of 1. This is to avoid artificial inflation of standard errors of independent variables due to the difference in scale between the well-being and thought variables. To account for multiple hypotheses testing, we apply the False Discover Rate Controlling Procedure (see Benjamini & Hochberg, 1995; Glickman et al., 2014) to the p-values reported below. All statistical tests were performed using STATA (SE 17.0).

Results

Fixed Effects Linear Probability Models

We first look at whether different activities are associated with different levels of TUT, positive and negative thoughts. For this, we focus on whether reporting a certain activity was associated with a report of TUT, while controlling for individual-level effects using fixed effects linear probability models. There are substantial disparities in the proportion of TUT reports depending on the activity. Indeed, the model shows that activities like working and studying are associated with significantly lower levels of TUT compared to the average other activities ($p < 0.001$), while activities like eating and drinking, commuting or social media are associated with significantly higher levels of TUT ($p < 0.001$). The probability of reporting TUT ranged from 0.25 for working, to 0.49 for eating and drinking. Models looking at company show that there are significant differences there too, with the company of colleagues being associated with the lowest amount of TUT (0.27) and the company of one's family and partner with the highest (0.44 and 0.46, respectively, $p<0.001$).

Figure 8 shows a breakdown of the probability of reporting TUT according to the fixed effects linear probability models predicting TUT using activities and company. Tables showing the full breakdown of results for the linear probability models predicting TUT and valence of thoughts can be found in the supplementary materials (Appendix A4).

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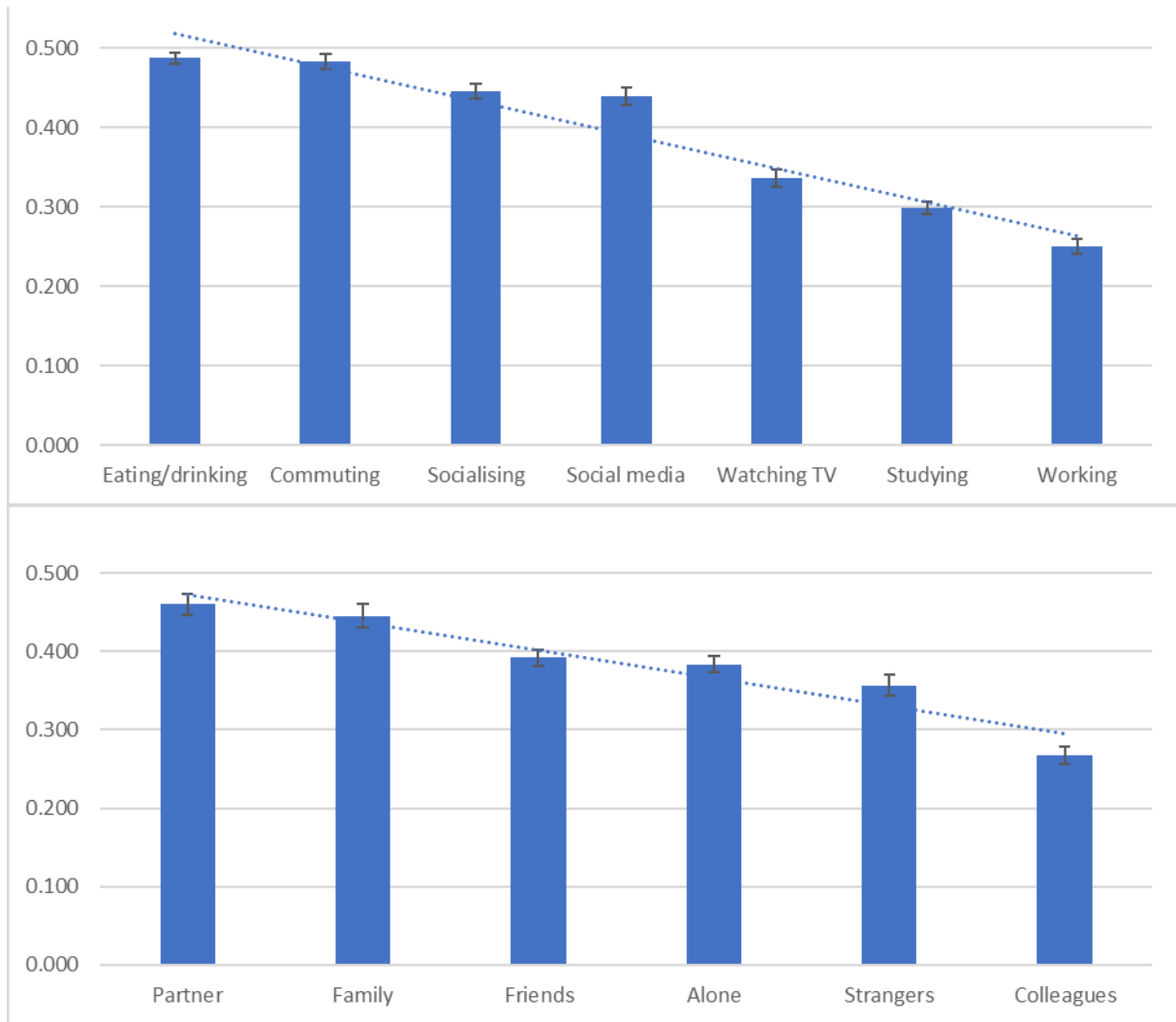
Figure 8: Probability of reporting TUT by activity and company according to the fixed effects linear probability models, in decreasing order of probability.

Similarly, models show large significant differences in the probability of reporting positive thoughts depending on the activity or the company. The lowest probabilities of reporting a positive thought are associated with using social media (0.48, $p < 0.001$) and being alone (0.48, $p < 0.001$). The highest probabilities of reporting a positive thought are associated with socialising (0.74, $p < 0.001$) and being in the company of friends (0.70, $p < 0.001$). We also find significant differences in the probability of reporting negative thoughts, although the absolute range of these differences is much smaller (from 0.11 when eating and drinking or socialising to 0.16 when commuting or using social media, $p < 0.001$). The company seems to matter less when it comes to the probability of reporting negative thoughts, with only being alone or with strangers showing significantly higher probabilities of reporting negative thoughts than the rest (0.15 and 0.14, respectively, $p < 0.01$).

We further run models predicting the specific content of TUT using the sub-sample of EMA entries that included a TUT report. Generally, contextual variables are less predictive of the probability of reporting specific social or temporal contents of TUT, although there are still some notable differences. For instance, people are more likely to report thoughts related to others when socialising and using social media than when they are working (p < 0.001). Working and studying are both associated with significantly more reports of self- and future-related thoughts (p < 0.001), while eating and drinking is associated with significantly less of these (p < 0.001). Finally, commuting and socialising are associated with significantly more past-related thoughts than the average other activity (p < 0.001).

Company predicted the probability of reporting specific contents of thought even less. Being in the company of friends or one's partner was associated with a significantly higher probability of reporting others-related thoughts (p < 0.001), while being with colleagues was associated with a significantly lower probability of reporting others-related thoughts (p < 0.001) than the average other activity. Being with colleagues or strangers seemed to predict more reports of self-related thoughts instead (p < 0.001), while being with one's partner predicted less reports of self-related thoughts (p < 0.001). Finally, being alone, with colleagues or with strangers was associated with significantly higher proportions of future-related thoughts than the average other activity (p < 0.001). All results for these models are shown in the supplementary materials (Appendix A4).

Fixed Effects Regressions (Happiness)

We then compare the effect of thought variables on happiness. The general model (i.e., with full sample, irrespective of activities) shows no significant relationship between TUT and people's reported happiness. Valence of thoughts plays a more important role, with both positive and negative thoughts being strongly related to reported happiness (to the magnitude of about 0.6 SD in either direction, p < 0.001). Content of TUT does not significantly predict happiness either after adjusting p-values for multiple hypotheses testing. Table 14 shows the breakdown of the general model, as well the activity-specific models that follow.

	General	Studying	Eating/drinking	Working
TUT	-0.011 (0.018)	-0.025 (0.036)	-0.006 (0.032)	-0.042 (0.065)
Valence				
Negative	-0.623*** (0.018)	-0.554*** (0.029)	-0.477*** (0.037)	-0.503*** (0.048)
Positive	0.605*** (0.013)	0.482*** (0.023)	0.538*** (0.027)	0.442*** (0.037)
Content				

Self	-0.020 (0.022)	0.041 (0.041)	0.024 (0.04)	0.076 (0.072)
Others	0.042 (0.021)	-0.008 (0.039)	0.090** (0.035)	-0.005 (0.07)
Past	-0.040 (0.022)	-0.085 (0.044)	-0.008 (0.04)	-0.054 (0.07)
Future	-0.017 (0.021)	-0.011 (0.04)	-0.046 (0.037)	0.062 (0.076)
C	-0.246*** (0.01)	-0.263*** (0.016)	-0.154*** (0.023)	-0.267*** (0.025)
N	15876	4463	3547	2016
Ind.	524	392	445	341
F	753.79	165.88	110.70	53.79
R^2	0.2559	0.2222	0.2002	0.1842

Table 14: Fixed effects regressions using thought variables (independent variables) to predict reported happiness (dependent variable) in general and by activity. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

	Commuting	Socialising	Watching TV	Social media
TUT	0.043 (0.052)	0.015 (0.052)	-0.06 (0.056)	-0.113 (0.058)
Valence				
Negative	-0.678*** (0.049)	-0.569*** (0.054)	-0.463*** (0.059)	-0.472*** (0.054)
Positive	0.474*** (0.04)	0.684*** (0.044)	0.587*** (0.041)	0.518*** (0.042)
Content				
Self	0.026 (0.058)	0.154* (0.063)	0.015 (0.069)	0.048 (0.061)
Others	0.035 (0.056)	0.032 (0.049)	-0.029 (0.062)	0.056 (0.058)
Past	0.056 (0.056)	-0.101 (0.052)	-0.029 (0.07)	-0.058 (0.062)
Future	-0.083 (0.056)	-0.152* (0.06)	0.031 (0.065)	0.066 (0.058)
C	-0.249*** (0.03)	-0.094* (0.042)	-0.303*** (0.031)	-0.364*** (0.03)
N	2080	1883	1636	1518
Ind.	409	369	326	301
F	68.01	76.62	54.57	49.60
R^2	0.2225	0.2625	0.2267	0.2230

Table 15 (con'd): Fixed effects regressions using thought variables (independent variables) to predict reported happiness (dependent variable) in general and by activity. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

The activity-specific models are largely congruent with the relationships highlighted in the general model. TUT are never predictive of reported happiness, regardless of the activity that people are engaged in. While the magnitude of the coefficients of positive and negative thoughts varies, their relationship with reported happiness also remains consistent across activities (all $p < 0.001$).

Small differences can be observed in the predictive effect of content variables depending on the activity. While the general model showed a significant association between others-related thoughts and reported happiness – albeit only before correcting for multiple

hypotheses testing –, this same relationship is only significant when people report to be eating and drinking ($\beta = 0.090$, $p = 0.010$). Aside from this, the only activity that shows a different association between thought content and happiness is socialising, where people report significantly higher levels of happiness alongside self-related thoughts ($\beta = 0.154$, $p = 0.014$), and significantly lower levels of happiness alongside future-related thoughts ($\beta = -0.152$, $p = 0.011$).

We observe more substantial differences in experiences of thoughts in the models that distinguish between different types of company. Indeed, while TUT are not predictive of happiness in general or in most circumstances, TUT are associated with a significant increase in reported happiness when people report being with their partner ($\beta = 0.168$, $p = 0.005$). Furthermore, self-related thoughts are negatively related to happiness when people report being alone ($\beta = -0.066$, $p = 0.018$), and positively related to happiness when people report being with colleagues ($\beta = 0.172$, $p = 0.008$).

Finally, past-related thoughts are associated negatively with happiness when people report being alone ($\beta = -0.078$, $p = 0.008$), while future-related thoughts are negatively related to happiness when being with friends ($\beta = -0.107$, $p = 0.016$). The full breakdown of company-specific results is shown in figure 9. A table detailing the full regression results can be found in the supplementary materials (Appendix A4).
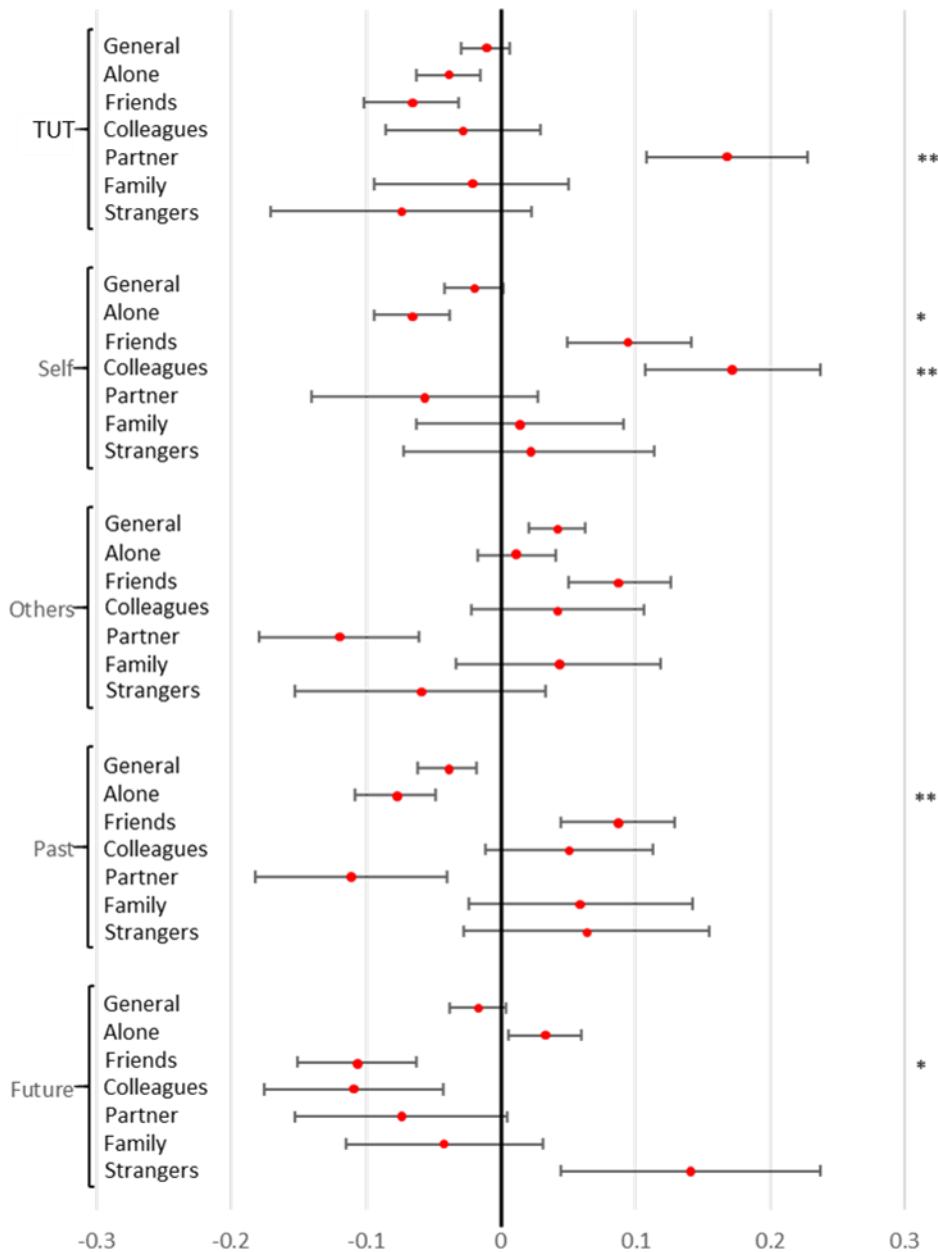
Figure 9: Forest plot of regression coefficients of TUT and each dimension of social and temporal content of TUT on experienced happiness (standardised) for every reported company, including standard errors. Standard errors are clustered on an individual level. *: p < 0.05, **: p < 0.01. Only results significant after multiple hypotheses testing correction are shown.

Fixed Effect Regressions (Worthwhileness)

The general model looking at the relationship between thoughts and worthwhileness shows a negative association between TUT and reported worthwhileness (β = -0.064, p < 0.001), as well as a positive association between thoughts related to self and worthwhileness (β = 0.069, p = 0.005). Valence of thoughts is still most strongly associated with variations in

the dependent well-being variable, although the magnitude of this association is lower for worthwhileness than for happiness (around 0.42 SD in either direction, $p < 0.001$). Focusing on the activity-specific models, however, we see that the negative relationship between TUT and reported worthwhileness is only present when people report studying ($\beta = -0.132$, $p < 0.001$). After adjusting for multiple hypotheses testing, there are no significant relationships between TUT and reported worthwhileness in any other activities. Figure 10 shows the relationship between TUT and experienced worthwhileness in general, by activity and by company.
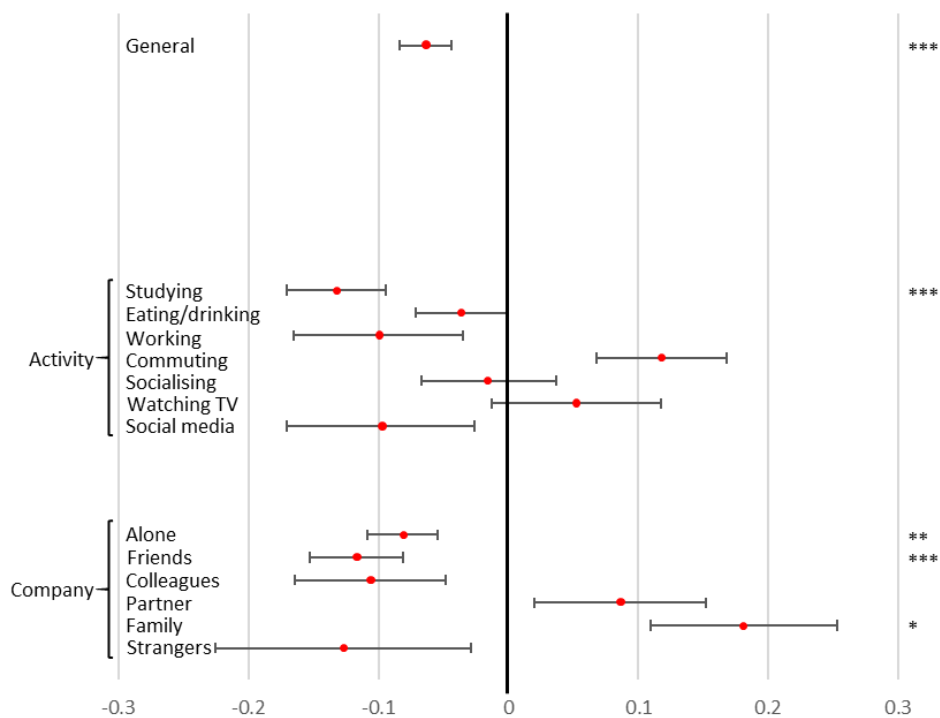
Figure 10: Forest plot of regression coefficients of TUT on experienced worthwhileness (standardised) for every reported company, including standard errors. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. Only results significant after multiple hypotheses testing correction are shown.

Like the results that were taken from the happiness models, there are very few significant relationships between content of thoughts and worthwhileness. Only thoughts related to self are positively related to reports of worthwhileness when people are socialising ($\beta = 0.155$, $p = 0.013$).

Finally, when comparing the relationship between thoughts and reported worthwhileness across different types of company, we observe that TUT are negatively associated with worthwhileness when people report being alone ($\beta = -0.081$, $p = 0.003$) or

with friends ($\beta = -0.117$, $p < 0.001$), but positively associated to worthwhileness reports when people are with family ($\beta = 0.181$, $p = 0.012$).

The type of company has similarly little to do with how content is associated with reported worthwhileness, with the large majority of coefficients remaining insignificant across models. The only exception is self-related thoughts, which are associated with higher worthwhileness when people report being with friends ($\beta = 0.192$, $p < 0.001$). Regression tables for all models using worthwhileness as the dependent variable can be found in the supplementary materials (Appendix A4).

Discussion

In this paper, we sought to investigate (1) whether people report different proportions of types, valences and contents of thoughts in different contexts, and (2) whether the relationship between thoughts and well-being differs depending on the context in which people report these thoughts. The study of mind wandering in different contexts had previously focused largely on experimental evidence or simulated environments. This study is the first of its kind to confirm the context regulation hypothesis, which posits that reports and reactions to TUT depend on the context in which they are experienced (Smallwood & Andrews-Hanna, 2013), in specific day-to-day contexts. This may have important implications for the way we understand thoughts, their antecedents and their consequences.

Proportions of thoughts

Among the activities that were taken into consideration, proportions of TUT reports vary from 25% (when people are working) to 49% (when eating and drinking). As expected, we find that activities that are more cognitively demanding, like studying and working, are associated with lower proportions of TUT reports than activities that require less focus or attention, such as commuting or eating and drinking. In addition, the more cognitively demanding activities of working and studying are associated with less positive thoughts, and more self- and future-related thoughts.

While it is clear that the attentional demands of an activity influence the proportion of TUT that are reported, we do not formally categorise all of the studied activities as either cognitively demanding or not, as we acknowledge that this distinction is not always obvious. For example, if working and studying can be said to be inherently cognitively demanding, and eating and drinking inherently not, activities like socialising or watching TV are more ambiguous, as they might require people to pay more or less attention depending on more

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specific parameters related to that activity. Nonetheless, the idea that people report more TUT in less cognitively demanding activities has been shown in the experimental literature as well (Mason et al., 2007; Smallwood & Andrews-Hanna, 2013), and our present findings suggest that the proportion of TUT that people report in a given activity might be a good indicator of how cognitively demanding it actually is in day-to-day settings. To confirm this, future research in this area might benefit from exploring how day-to-day activities can be classified in terms of how much attention they require, or from designing studies that ask people about the attentional requirements of the activity in the EMA questionnaire itself.

Large differences in the proportion of TUT reports are also found across the different types of company that people report (27% with colleagues vs 46% with partner). There appears to be a relationship between how well people know those that they are spending time with and the proportion of TUT that they report in their company. Indeed, people report the highest proportions of TUT when they are in the presence of their partner or their family, followed by their friends, and they report the least amount of TUT in the presence of strangers and colleagues. This may indicate that people allow their mind to wander more around people they feel more comfortable with.

In addition, socialising is associated with the highest proportion of positive thoughts out of all considered activities. In terms of company, being alone is associated with the lowest proportion of positive thoughts, and the highest proportion of negative thoughts. This would suggest that people's company tends to be preferrable to being alone. In general, people report more positive and less negative thoughts around people they are more familiar with (i.e., partner, family, friends) than when they are with strangers or colleagues.

Hence, context, both in terms of the activities that we engage in and the company that we keep, is a strong predictor of how much our mind wanders and of the valence of our thoughts. When it comes to activities, our data support the previously formulated hypothesis that our mind wanders more in less cognitively demanding activities (Smallwood & Andrews-Hanna, 2013). It appears that company that is associated with more positive thoughts is also associated with higher proportions of TUT. This is consistent with the literature showing that people have a broader scope of attention when they experience positive emotions versus negative ones (Fredrickson & Branigan, 2005; Wegbreit et al., 2015). Indeed, a broader scope of attention tends to be associated with more comfortable

situations or contexts, which aligns with our finding that people allow themselves more TUT in more familiar company.

As such, our findings suggest an association between the thoughts that people report and how comfortable their context is. Even though the idea that more comfort is associated with more TUT reports needs to be confirmed in other studies, we suggest that this may be an entirely unexplored dimension of context that drives people's propensity to engage in mind wandering. Indeed, while it is well-established that the attentional requirements of an environment, task or activity are related to how often we let our minds wander, no previous study has looked at how comfortable participants felt in the context in which they reported their thoughts. By showing that people report more TUT, more positive and less negative thoughts around people that they are more familiar with, we introduce the possibility that, besides a cognitive dimension (i.e., the cognitive demands or attentional requirements of an activity), there is an emotional dimension to people's external context that also affects what kind of thoughts they are experiencing. This emotional dimension may be driven predominantly by the familiarity of the company that people are in, but one could imagine that other factors may play a role, such as how familiar or comfortable their physical environment is.

Alternatively, it could be that different types of company are associated with different levels of active social interactions. For example, it may be that people report higher proportions of TUT around their partner or their family simply because they spend more of the time in these types of company being disengaged, or focused on something else entirely. While we do not find strong correlations between the activity and the company that people report, it could be that capturing how actively (or intensely) people are engaged in the social interactions that they are reporting would better explain our findings than the level of comfort that people are experiencing. Future research may therefore also benefit from incorporating a measure of *intensity* of social interactions to explore these potential mechanisms in more depth.

Effect of thoughts on experienced happiness and worthwhileness

Despite the large differences in the proportions of TUT, valence or content that are found across activities, the effect of these thought variables on reported happiness is remarkably consistent across activities. While this does not rule out that the relationship between thoughts and experienced happiness differs across different sets of activities, it

suggests that people may not experience their thoughts differently depending on what they are doing, at least in terms of happiness. This seems to be in alignment with conclusions drawn by the recent study that looked at interactions between context and content of thoughts (Nyklíček et al., 2021).

However, this is only the case when considering the aspect of context that the previous literature has focused on. To date, the main variable of context that has been considered in day-to-day settings when it comes to exploring the relationship between thoughts and well-being has been the activity that people are engaged in (e.g., Killingsworth & Gilbert, 2010; Nyklíček et al., 2021). While activities are undoubtedly an important and often salient element of context, we argue that the company that people are in may be just as important and salient. In fact, it is the company that people are in that appears to be more important for the way they experience different types and contents of thoughts in relation to their happiness. Indeed, while TUT are generally not associated with significant variations in happiness, people report significantly higher happiness when they report TUT while being with their partner.

While the data gathered for the present study allow only speculations as to the possible reasons for this finding, we can imagine that the presence of one's partner allows our thoughts to drift towards more pleasant topics; an idea that is supported by the higher proportion of positive thoughts that people report when being with their partner. As being with one's partner was also associated with higher levels of experienced happiness in general, this explanation would also align with associative network theory, which suggests that people would experience more positive thoughts in contexts where they are happier too (see Bower, 1981). This further supports the idea that there might be an emotional dimension to the way context affects the type and content of thoughts that people report, and possibly the relationship between thoughts and well-being as well. Indeed, the comfort associated with being with our partner may also play a role in how much happiness we derive from letting our mind wander. Alternatively, it could be that the increased levels of happiness (and comfort, presumably) that we experience around our partner might invite more reports of mind wandering. While we cannot be certain about the causal direction of this mechanism, both explanations support the existence of this emotional dimension of context.

Furthermore, the company that people report, or lack thereof, gives us greater insights into how people react to the content of their thoughts. Both self- and past-related thoughts are

associated with lower happiness when people are alone. This may be explained by the idea that people focus on different aspects of themselves or of their past when they are alone vs when they are in the company of others. We also observe significant differences in the relationships between others- and future-related thoughts depending on people's company. As such, while it is unclear whether there is a time and a place for certain types and contents of thoughts, there does appear to be a company for them.

Applying this contextual lens to the relationship between thoughts and worthwhileness, we see that the specific activity that someone is engaged in matters in terms of how they experience TUT. While the general model suggests that TUT are associated with significantly lower reports of worthwhileness, the activity-specific models reveal that this negative relationship is in fact driven by a strong negative relationship between TUT and worthwhileness *when studying*. Indeed, there is no significant evidence for this negative relationship across other activities. The same can be said when looking at company, as we find that the negative relationship between TUT and worthwhileness is in fact only present when people report being alone or with friends, and there is a positive relationship between the two when people are with family.

While the mechanisms driving these relationships are unclear, it could be that the experience of worthwhileness that people report is an assessment of how purposeful their thoughts are relative to how purposeful they perceive their context to be. As such, the experience of an activity like studying may be more dependent on whether we are able to dedicate our full attention to it than the other activities that we explored in this study. It is plausible, then, that TUT would be systematically related to worse experiences of worthwhileness, regardless of their content or valence, when participants are studying, but not when they are engaged in most other activities. Alternatively, it may be that certain contexts are more conducive to TUT that are associated with certain well-being experiences. For example, TUT that participants report when they are alone may be less engaging or meaningful than when they are with family, resulting in less worthwhile experiences of TUT in general. This would align with previous findings that showed that people go to great lengths to avoid focusing on their thoughts when they are alone (Wilson et al., 2014), as well as with the importance of the emotional dimension of context.

Even though we can only speculate about these mechanisms, the present findings reject the idea that TUT or mind wandering are phenomena that affect well-being in an

exclusively negative way, which had already been called into question in recent literature (e.g., Franklin et al., 2013; Welz et al., 2018). This study offers more comprehensive insights into when such thoughts might actually be beneficial or detrimental to well-being. TUT are generally neither positively nor negatively related to well-being, as they are not significant predictors of happiness or worthwhileness across most activities and companies in which these relationships were analysed. Rather, TUT might be beneficial for well-being when people report being in the company of close relatives (i.e., partner or family), but potentially detrimental to people's experiences of worthwhileness in more cognitively demanding activities (i.e., studying).

Limitations, further research and concluding remarks

While these findings need to be supplemented with research across different contexts (e.g., cultural; see Martinon et al., 2019) and different dimensions of thoughts (e.g., intentional vs unintentional TUT; see Seli et al., 2016, 2017), they provide a starting point towards a more nuanced approach to the study of thoughts and well-being. Additionally, they draw attention to the possibility that the emotional dimension of people's context may have been an underexplored factor contributing to the way people experience thoughts. This may also complement recent developments in the space of emotion regulation, which have established that emotion reappraisal through changing one's thoughts may be an effective tool to improve well-being (e.g., Colombo et al., 2020; Newman & Nezlek, 2021).

Indeed, understanding what kinds of thoughts people have in a certain context, and how those thoughts are susceptible to make them feel, has implications for individual well-being enhancing interventions. It is a necessary step towards creating robust empirical frameworks for mental health apps, which currently are unable to provide adequate personalised or context-specific advice and services to their users (Bakker et al., 2016). Specifically, further research of this kind could be used to tailor the interventions that such apps offer to the context that the individual reports, while informing participants of how their context might affect both their thoughts and their reactions to these thoughts (e.g., Brockman et al., 2017).

The current study is limited by several factors. Firstly, it uses a student population, which may not be representative of the general population, neither of the UK, nor of the world. This also means that the activity that participants reported most often was "studying",

which is obviously less widespread across the general population, and may therefore not be the most insightful activity to consider when attempting to generalise these findings.

Secondly, this study was exploratory in nature. Because of this, the activities and types of company included in this study were selected based on frequency of reports rather than on the activities that have previously garnered most interest from researchers. As such, activities like exercising (e.g., Latinjak, 2018), reading (e.g., Feng et al., 2013) or meditation (e.g., Jazaieri et al., 2016), which have been studied previously in relation to thoughts, were not included in the analysis. To remedy this, future research could design studies to address specific hypotheses relating to a broader, more targeted set of activities.

Finally, this paper is limited by some of the design features of EMA. While EMA is the most widespread tool to collect ecologically valid self-reported measures, it remains a relatively intrusive data collection method that is prone to attrition and selection biases. A discussion of attrition in this sample can be found in the supplementary materials (see chapter 2 and general discussion).

Beside this, future research might focus on other elements of context, like location (e.g., indoors vs outdoors), weather, the degree of familiarity of these contextual variables (e.g., one might expect unfamiliar activities or locations to be associated with different reports of thoughts and perhaps different relationships between these thoughts and well-being reports), or the broader social context (e.g., restrictions or changes in activities due to Covid-19; see Lades et al., 2020). In doing so, it should take into consideration the distinction between the cognitive and emotional dimensions of context in an attempt to assess their relative weight in predicting both the occurrence of different types, contents and valences of thoughts, and their relationship to well-being. In addition, similar research might consider other well-being variables, namely, life satisfaction, anxiety, or more specific ranges of moods (e.g., PANAS, Watson et al., 1988). Finally, a more granular approach to the study of thoughts and well-being would not be complete without the inclusion of individual-specific characteristics (e.g., personality, self-esteem, risk attitudes, etc.; e.g., Robison et al., 2020; Welhaf et al., 2020) as moderators of the predictive effect of thoughts on the various dimensions of well-being.

To conclude, context matters in terms of how people experience their thoughts. To properly estimate the relationship between what we think and how we feel, we must take into account the context in which these thoughts and feelings occur and are reported. Only by

acknowledging these contextual drivers of our internal experiences can we hope to inform the development of more nuanced and specialised well-being enhancing tools that can truly benefit the individual user.

Chapter 6:

Reporting well-being, thoughts and context reduces anxiety

Abstract

Increased focus on well-being and mental health in the past decades has made the development of well-being enhancing interventions an important objective for policymakers and social scientists alike. Reporting on well-being has the potential to be a relatively easy and impactful intervention, yet research exploring the impact of well-being reports on well-being and mental health is still in its infancy. In this paper, we discuss three Randomised Controlled Trials that show that regularly reporting well-being, thoughts, and their context, even for a few days, significantly reduces anxiety. Across all studies, participants of diverse socio-cultural backgrounds completed daily Ecological Momentary Assessment (EMA) and/or Day Reconstruction Method (DRM) well-being questionnaires for two to three weeks and showed small to medium-sized reductions in self-reported anxiety as a result (d = [0.18, 0.36]). Effect sizes were comparable to existing behavioural and positive psychology interventions, suggesting that the simple act of reporting contextualised thoughts and well-being may be as effective at improving people's well-being as more complex and time-consuming interventions.

Introduction

Heisenberg's landmark quote "to observe is to disturb" asserts that the simple act of observing alters the system that is studied, summarising his uncertainty principle (Heisenberg, 1930). When it comes to well-being research, surprisingly little is known about how measuring people's well-being impacts their well-being, i.e., *the system* that is studied. The Ecological Momentary Assessment (EMA), which captures momentary experiences multiple times a day, and the Daily Reconstruction Method (DRM), a one-off record of retrospective accounts of the previous day, are two of the most common ways of capturing well-being (Kahneman et al., 2004; Lades et al., 2022; Lucas et al., 2021; Stone & Shiffman, 1994, 2002). Both involve asking people to report their well-being levels, thoughts, and the surrounding context. In this paper, we explore the possibility that these well-being measurement tools have a by-product impact on people's well-being. Specifically, they might

help people to contextualise their affective experience, resulting in heightened levels of reflection and affective awareness.

The idea that paying attention to how we feel can help us to feel better is a long-standing one in philosophy and psychiatry (Cloninger, 2006; Pennebaker, 1997). As such, there is much to gain from understanding how reporting on well-being impacts well-being in turn. This work builds upon existing literature highlighting the benefits of paying attention to how we feel and explores whether repeatedly reporting on well-being, thoughts, and the context within which they are experienced can improve well-being and overall mental health. In doing so, it makes an important contribution to intervention science literature, which has called for more research exploring the impact of specific intervention components on psychological outcomes (Firth et al., 2017; Holmes et al., 2014; Patel et al., 2018; Sin & Lyubomirsky, 2009).

Among the few studies that have investigated the impact of reporting well-being on well-being, one found that reporting happiness levels several times a day for 2 weeks accentuates pre-existing levels of mental health – namely, people with relatively poor mental health were worse off, while people with better mental health were better off (Conner & Reid, 2012). Notably, this research did not include thoughts and context (i.e., activities, company, and location) alongside well-being reports, which might not have allowed participants to reflect more broadly on their day-to-day life and contextualise their feelings. There is, however, some evidence that completing daily questionnaires like EMA helps people increase their awareness of how they feel (Widdershoven et al., 2019), and that this kind of awareness can help prevent depression or function as an early intervention against it (Beames et al., 2021). Even so, most studies merely use EMA in combination with other interventions, thus not allowing researchers to isolate the effect of completing EMA and/or DRM as a stand-alone intervention (Balaskas et al., 2021; Myin-Germeys et al., 2016, 2018; Schueller et al., 2017).

To the best of our knowledge, the only research that gathered positive and negative affect reports alongside contextual reports (in this case, of activities and company) explored their impact only in clinical settings and found this to be effective in reducing short-term symptoms of depressed participants (Kramer et al., 2014). They also found that having psychologists or psychiatrists provide weekly face-to-face feedback on how patients' affect and depression levels were related to their daily activities produced even stronger, longer-

term effects, suggesting that guiding people in the process of reflecting on how they feel may be even more beneficial than merely making them report their internal states. Yet, the impact of contextualised well-being reports on different facets of mental well-being remains insufficiently explored, particularly across different time points and cohorts.

We recognise two potential underlying reasons why reporting on how we feel, what we think about and what we do might be associated with how we feel more generally. Firstly, identifying and distinguishing between different feelings is thought to help people better respond to those experience, since it enables a more specialised and therefore adaptive response (Kashdan et al., 2015). For example, people who experience their emotions with higher granularity, i.e., using more words to describe both positive and negative emotions, are less likely to use maladaptive coping strategies (such as aggression and self-medicating; Kashdan et al., 2010) and are more likely to use positive emotion regulation strategies that target the specific emotion (Barrett et al., 2001). Similarly, interventions that train people to improve their emotion differentiation before aversive experiences have been shown to reduce anxiety during those experiences more than cognitive reappraisal and distraction (Kircanski et al., 2012). It follows that contextualising well-being reports by complementing them with thoughts and external context reports may be particularly important, especially given extensive evidence that both thoughts and activities are strongly related to well-being (Killingsworth & Gilbert, 2010; Smallwood & Schooler, 2015; Stawarczyk et al., 2012; White & Dolan, 2009).

Secondly, reporting well-being, thoughts and their context may help to increase affective awareness. It has been suggested that awareness of one's thoughts and feelings facilitates emotional stability by shifting attentional focus away from the direct experience of these feelings and promoting emotional acceptance (Coffey et al., 2010; Fogarty et al., 2015; Frewen et al., 2008). Interventions inducing such kinds of awareness have also been shown to encourage reflection through identification of thoughts and feelings without judgement (Louet, 2015). They have also been shown to produce improvements on a variety of well-being indices including anxiety and depression (Enkema et al., 2020; Hofmann et al., 2010). Relatedly, there is a compelling body of evidence showing that poor interoceptive awareness is associated with emotion regulation difficulties (Price & Hooven, 2018).

Our study is the first of its kind to evaluate whether the simple act of reporting one's well-being, thoughts and the context within which they are experienced affects overall mental

well-being across multiple facets, including life satisfaction, happiness, worthwhileness, anxiety, depression, and stress. To this end, we present the results of three randomised controlled trials (RCT) in which participants were asked to complete EMA and/or DRM questionnaires reporting their well-being and thoughts every day for two to three weeks alongside reports of activities, company, and location. The findings of this research suggest that merely repeating a simple reporting exercise, which can be easily practiced without professional mental health support, alleviates anxiety. Furthermore, this study reveals the side effects of using EMA and DRM for research purposes, providing insights into the observed psychological benefits across different well-being and mental health indices, thus deepening our understanding of the relationship between psychological processes and outcomes (Fried et al., 2014).

Methods

Design

We analyse the impact of repeatedly reporting thoughts, activities and well-being over two weeks on well-being across three Randomised Control Trials (RCT). Study 1 and 2 asked participants to download an app, which randomly assigned them to either a control or a treatment group. In the treatment group, participants were asked to complete up to five Ecological Momentary Assessments (EMA) and one Day Reconstruction Method questionnaire (DRM) every day for three (study 1) and two weeks (study 2). These questionnaires asked them about what they were doing, who they were with, where they were, what they were thinking about and how they were feeling.

In contrast, the control group was also notified five times a day to answer EMA-type questionnaires, and once to fill in a DRM, but was not asked to report their well-being in any of these questionnaires. Both treatment and control groups filled in identical onboarding and exit questionnaires at the beginning and end of the study. These questionnaires included the ONS-4 well-being measures (i.e., life satisfaction, worthwhileness, happiness and anxiety).

In study 3, participants were sorted into four possible groups, including a control and a DRM group. In the DRM group, participants were asked to download an app that asked them once a day over the course of two weeks to fill in a DRM questionnaire about their activities, company, thoughts and feelings of the previous day. The control group was asked to fill in only the onboarding questionnaire, and subsequent questionnaires after week 2 and 4 of the study. The other two treatments involved the use of an additional app by participants,

which served as a separate well-being intervention in itself. Participants in these treatments were excluded from the present study.

Regardless of whether participants in the treatment group were filling in EMAs or DRMs, they were asked to report the same information. This included the activity that they were engaged in (either in the moment for EMA questionnaires, or reflectively in DRM questionnaires), who they were with, where they were, and what they were thinking about. In addition, they were asked how *happy* they were feeling (on a scale of 0 to 10), and how *worthwhile* they felt what they were doing was. As such, while the onboarding and exit questionnaires asked participants to reflect on life satisfaction and anxiety too, participants did not reflect on these two measures throughout the RCT. Participants in studies 1 and 2 were also asked to fill in an emotions grid at the end of each EMA, asking them which emotion best described their current state.

As part of the DRM, participants were asked to provide a full account of what they did the day before, from the moment they woke up to the moment they went to sleep. For this, they first indicated the timeframe in which an activity occurred, after which they answered all the abovementioned questions for that timeframe. They then repeated this until the entire day was divided into a series of timeframes corresponding to every activity they were engaged in.

In addition to this, the last EMA of every day asked participants to answer some additional questions to reflect on their day as a whole. These questions asked them to rate their day overall in terms of life satisfaction, worthwhileness, happiness and anxiety, on a scale of 0 to 10. They were then asked about how much time they slept the previous night (in 1-hour increments), how much time they spent doing sports, how productive they were and how much time they spent with friends.

In addition to the ONS-4 questions that were also collected in studies 1 and 2, several scale-based measures of mental well-being were added to the onboarding, week 2 and week 4 questionnaires in study 3. As such, the Perceived Stress Scale (PSS-10), the Generalised Anxiety Disorder Assessment (GAD-7), the WHO Well-Being Index (WHO-5), and the Patient Health Questionnaire depression scale (PHQ-8) were also collected at each time-point.

Inclusion criteria and analysis

Prior to analysis, we determine identical inclusion criteria for participants across all three studies. Since all participants across the three studies were asked to fill in DRM questionnaires (i.e., 21 in study 1, 14 in studies 2 and 3, one for every day over a two-week time period), we use the number of DRM filled in as a benchmark for whether or not individuals could be said to have received the "treatment". As such, we include all participants who fill in at least five DRM questionnaires, as well as the onboarding and exit questionnaires. To avoid excluding people from study 1 and 2 who satisfied the inclusion criteria of study 3, we do not set a minimum number of completed EMA.

Impact of the treatment on well-being is assessed by comparing the deltas between onboarding and exit questionnaire values of each well-being measure, in each study. Since distributions of well-being reports on 0-10 scales tend to be skewed (towards more positive outcomes), we use non-parametric tests (Mann-Whitney U) for this. We focus predominantly on between-group differences, and report two-sided p-values throughout the manuscript, to account for the fact that no specific predictions were preregistered in the first two studies.

Using the overall sample standard deviation of each well-being and mental health measure, we compute Cohen's *d* to assess the magnitude of the significant effects. Finally, we run simple linear regressions using the number of EMA and DRM questionnaires answered as explanatory variables to predict changes in the relevant mental well-being measure in the treatment group. These models are used to confirm that answering more questionnaires is indeed associated with greater improvements in well-being, as should be the case for all well-being variables for which the treatment was effective.

Measures

For the purpose of this paper, we focus only on the well-being and mental health measures that participants answer in the onboarding and exit questionnaires of each study. Measures common to all studies are the well-being questions as formulated in UK national surveys administered by the ONS (Dolan & Metcalfe, 2012). These consist of four questions asking about general life satisfaction, general sense of worthwhileness, happiness yesterday and anxiety yesterday. These questions are complemented by two additional ones asking about happiness and anxiety in general. All questions are answered on a scale of 0 to 10, and can be found in table 16 below.

ONS well-being questions

Overall, how satisfied are you with your life?
Overall, to what extent do you feel the things you do in your life are worthwhile?
Overall, how happy did you feel yesterday?
Overall, how anxious did you feel yesterday?
Overall, how happy do you feel in general?
Overall, how anxious do you feel in general?

Table 16: ONS-4 well-being questions, extended to include questions about general happiness and anxiety.

In addition to the ONS well-being questions, study 3 includes additional scale-based measures of stress, anxiety, well-being, depression, resilience and sleep. Each scale is briefly detailed below.

GAD-7. The Generalised Anxiety Disorder Assessment is a 7-item scale that assesses anxiety levels in participants in a more detailed manner than the ONS-4 anxiety questions (Spitzer et al., 2006). Participants are asked to rate items based on the following question: "Over the last week, how often have you been bothered by the following problems?" Items all focus on negative, anxiety-related emotions (e.g., "Feeling nervous, anxious, or on edge") and are rated on a 4-point scale of 0 ("Not at all sure") to 3 ("Nearly every day"). Scores are added up to reflect overall anxiety levels. Typically, scores of 5-9 are associated with mild anxiety, 10-14 with moderate anxiety and 15-21 with severe anxiety. Cronbach's $\alpha = 0.87$ (study 3).

PSS-10. The Perceived Stress Scale is a 10-item scale that assesses stress levels in participants (Cohen et al., 1983). Items ask participants how often they feel certain stress-related emotions about various aspects of their day-to-day lives (e.g., "In the last week, how often have you been upset because of something that happened unexpectedly?"). The scale is composed of six negative items and four positive ones, which participants are rating on a 5-point scale of 0 ("Never") to 4 ("Very often"). Positive items are reverse-coded, and scores are added up to reflect overall stress levels. Conventionally, scores of 0-13 indicate low stress, 14-26 moderate stress, and 27-40 high perceived stress levels. Cronbach's $\alpha = 0.86$ (study 3).

WHO-5. The World Health Organisation-Five Well-Being Index is a 5-item scale that assesses general well-being by focusing on positive emotions (Topp et al., 2015). The questionnaire asks participants to indicate how often they have been feeling a certain way over the past week (e.g., "I have felt cheerful and in good spirits"). Participants are asked to indicate this using a 6-point scale of 0 ("At no time") to 5 ("All of the time"). The score is

computed by adding up all answers. Scores of 12 or less out of 25 are understood to be indicators of poor well-being. Cronbach's α = 0.84 (study 3).

PHQ-8. The Patient Health Questionnaire depression scale is an 8-item scale that was designed to diagnose depression and assess its severity (Kroenke & Spitzer, 2002). It asks people: "Over the last two weeks, how often have you been bothered by any of the following problems?", and items focus on negative feelings associated to day-to-day activities (e.g., "Little interest or pleasure in doing things?"). Participants rate each item on a 4-point scale analogous to the GAD-7 one (from 0, "Not at all sure" to 3, "Nearly every day"). The final score is computed by adding up the rating of all items. Scores of 5–9 are considered indicators of mild depression, 10–14 moderate depression, 15–19 moderately severe depression and 20-24 severe depression. Cronbach's α = 0.84 (study 3).

Study 1

Procedure. In study 1, we asked adults in four Spanish-speaking countries (Spain, Chile, Columbia and Peru) and the UK to download an app called Reflections, which was designed for the purposes of this study. The study took place between February and August 2018. Participants first filled in an onboarding questionnaire, then were randomly sorted within the app into a control and a treatment group. One third was assigned to the control group, and two thirds to the treatment. Participants group were notified to answer five EMAs and one DRM every day over the course of three weeks. In the treatment group, they answered questions related to their thoughts, well-being, activities, company and location. In the control group, they answered the same questions, except for those relating to well-being, which were replaced by random questions asking them to rate something on a 0-10 scale (e.g., "How much do you like reading books?"). Upon completion of the study, they were then prompted to answer a final survey asking them to report on the same well-being measures as in the onboarding survey.

Participants were paid €40 (or $45) upon completion of the study. They were considered to have completed the study if they answered at least 80% of questionnaires and filled in both the onboarding and exit questionnaires.

Participants. In total, 691 participants completed the onboarding survey and were allocated to the control and treatment groups. Of these, 396 participants completed at least five DRM questionnaires (either sham or real), as well as the onboarding and exit questionnaires. As such, our final sample is composed of 123 participants in the control

group, and 273 participants in the treatment group. Of these, the majority were from Spain (47.0%), and 8.3% were from the UK. 36.1% of the sample was female, 30.6% were students, and 43.9% were employed. 68.2% of participants reported being between 26 and 34, while 11.1% were younger, and 18.2% reported being between 35 and 44.

Descriptive statistics. In table 17 below, we report the mean and standard deviation for each measure of well-being that participants answered in the onboarding survey. We check for significant differences between onboarding starting values of each statistic between the control and treatment group. We find that these groups do not significantly differ in terms of starting point for five of the six ONS measures. Reports of happiness yesterday appeared to be significantly higher in the control compared to the treatment group ($p = 0.030$).

	Treatment mean (SD)	Control mean (SD)	Significance of diff.
Life satisfaction	7.03 (1.63)	7.15 (1.67)	NS
Worthwhileness	7.26 (1.73)	7.37 (1.71)	NS
Happiness yesterday	6.95 (2.04)	7.43 (1.93)	*
Anxiety yesterday	5.56 (2.62)	5.21 (2.82)	NS
Happiness in general	7.22 (1.62)	7.29 (1.66)	NS
Anxiety in general	5.71 (2.32)	5.22 (2.37)	NS

*Table 17: Mean reports of well-being reports on ONS measures in treatment and control groups in the onboarding questionnaire of study 1, including significance of difference based on Mann-Whitney U tests (NS: not significant, *: p < 0.05).*

There are no significant difference between the control and the treatment group in terms of gender, age, employment or student status at the start of the study.

Study 2

Procedure. Data for study 2 were collected between January and February 2019. We asked LSE students to download the same app (Reflections) that was used in study 1. Procedure was the same as study 1, except that this time, only around one quarter of participants were randomly allocated to the control group in which all well-being related questions were replaced with random questions (e.g., "How much do you like reading books?").

Participants were paid £20 upon completion of the study. They were considered to have completed the study if they answered at least 70% of questionnaires and filled in both the onboarding and exit questionnaires. Completion requirements were adjusted downward after the first study to avoid excessive drop-outs from people who had already missed a few questionnaires early on in the study. In addition, participants who filled in at least the

onboarding survey were paid £5 for partial completion, if they did not meet the required completion threshold. Hypotheses specific to the current study were preregistered as part of a larger study assessing overall well-being of LSE students and its determinants (https://osf.io/yt745).

Participants. In total, 666 LSE students filled in the onboarding survey, of which 348 satisfied the inclusion criteria as previously specified. The final sample was therefore composed of 93 participants in the control group and 255 in the treatment group. 64.7% of the final sample was female, and 15.5% reported being employed. The large majority of participants were younger than 26 (82.6%).

Descriptive statistics. In table 18 below, we show the mean and standard deviation for all well-being measures in the treatment and control groups, respectively, in the onboarding questionnaire. In study 2, there were no significant differences in the well-being levels reported by people in either group. Similarly, there were no significant differences in the gender, age and employment distributions across these groups.

	Treatment mean (SD)	Control mean (SD)	Significance of diff.
Life satisfaction	6.91 (1.54)	6.79 (1.57)	NS
Worthwhileness	6.86 (2.10)	7.08 (1.77)	NS
Happiness yesterday	6.59 (1.98)	6.59 (2.03)	NS
Anxiety yesterday	5.20 (2.57)	4.86 (2.63)	NS
Happiness in general	6.78 (1.63)	6.78 (1.60)	NS
Anxiety in general	5.52 (2.33)	5.17 (2.33)	NS

Table 18: Mean reports of well-being reports on ONS measures in treatment and control groups in the onboarding questionnaire of study 2, including significance of difference based on Mann-Whitney U tests (NS: not significant, *: p < 0.05).

Study 3

Procedure. In study 3, conducted between March and April 2021, we asked LSE students to download a new app called LSEasy, which notified them once a day to complete a DRM. Rather than downloading the app, the control group only completed the onboarding and the exit questionnaires, which were sent outside of the app. There were two other treatments in the study, in which people were asked to download a second app, called Foundations, that provided participants with well-being interventions. Participants were randomly placed into any of these four groups with equal probability. In addition, participants were asked to report their well-being and mental health immediately after the two weeks of

the study, while the exit questionnaire was send two weeks after that, in week four of the study.

Participants were paid £30 upon completion of the study. Participants in the treatment group were considered to have completed the study if they answered at least 70% of questionnaires and filled in both the onboarding and exit questionnaires. Participants in the control group were required to answer only the onboarding and subsequent check-up questionnaires at week 2 and 4 of the study. Hypotheses specific to the current study were preregistered as part of a larger study assessing the impact of mobile apps on well-being (https://osf.io/hvtf8).

Participants. In total, 610 LSE students filled in the onboarding survey, of which 306 were split between in the control and LSEasy treatment groups. Of these, 214 satisfied the inclusion criteria for this paper. The final sample was therefore composed of 129 participants in the control group and 85 in the treatment group. We note that the higher attrition in the treatment group is linked to both the requirement for participants to download an additional app and to the fact that participants in the control group did not need to fill in any DRM questionnaires, and were therefore not subject to the inclusion criteria. 68.7% of the final sample was female, with 24.8% of participants also reporting some form of employment. 83.7% of remaining participants were between 18 and 26 years old.

Descriptive statistics. Table 19 below shows the means and standard deviations for all well-being and mental health measures that participants reported in the onboarding questionnaire. We find no significant differences in mean reported between treatment and control groups for any of these measures. Similarly, there were no significant differences in age, gender and employment distributions between the two groups.

	Treatment mean (SD)	Control mean (SD)	Significance of diff.
Life satisfaction	6.49 (1.78)	6.50(1.79)	NS
Worthwhileness	6.64 (1.87	6.63 (1.87)	NS
Happiness yesterday	6.08 (1.96)	5.94 (2.38)	NS
Anxiety yesterday	5.72 (2.20)	5.56 (2.41)	NS
Happiness in general	6.52 (1.56)	6.19 (1.61)	NS
Anxiety in general	5.74 (2.08)	5.61 (2.16)	NS
GAD-7	8.70 (5.56)	8.35 (5.26)	NS
PSS-10	22.90 (3.77)	22.23 (3.89)	NS
PHQ-8	9.58 (5.31)	9.20 (5.75)	NS
WHO-5	11.04 (5.15)	10.77 (4.64)	NS

Table 19: Mean reports of well-being reports on ONS, GAD-7, PSS-10, PHQ-8 and WHO-5 measures in treatment and control groups in the onboarding questionnaire of study 3, including significance of difference based on Mann-Whitney U tests (NS: not significant, *: p < 0.05).

Results

Study 1

To test whether there was a significant effect of the treatment on well-being, we take the difference between the well-being scores pre- and post-study in the control and treatment groups, and compare these differences to each other. We find no significant effects of repeatedly reporting well-being and thoughts alongside context on life satisfaction (difference in improvement between treatment and control group = 0.14, p = 0.253), worthwhileness (diff. = -0.06, p = 0.928), happiness *yesterday* (diff. = 0.53, p = 0.071) or happiness *in general* (diff. = 0.07, p = 0.371). However, we find that anxiety is significantly reduced as a result of the treatment (both anxiety *yesterday*, diff. = -0.96, p = 0.002; and anxiety *in general*, diff. = -0.70, p = 0.014).

Specifically, we find that anxiety *yesterday* is significantly reduced in the treatment group (diff. = -0.70, p = 0.004), but not in the control group (diff. = 0.26, p = 0.423). Similarly, participants in the treatment group report a reduction in anxiety *in general*, albeit an insignificant one (diff. = -0.44, p = 0.061), while participants in the control group reported an insignificant increase in anxiety *in general* (diff. = 0.26, p = 0.453).
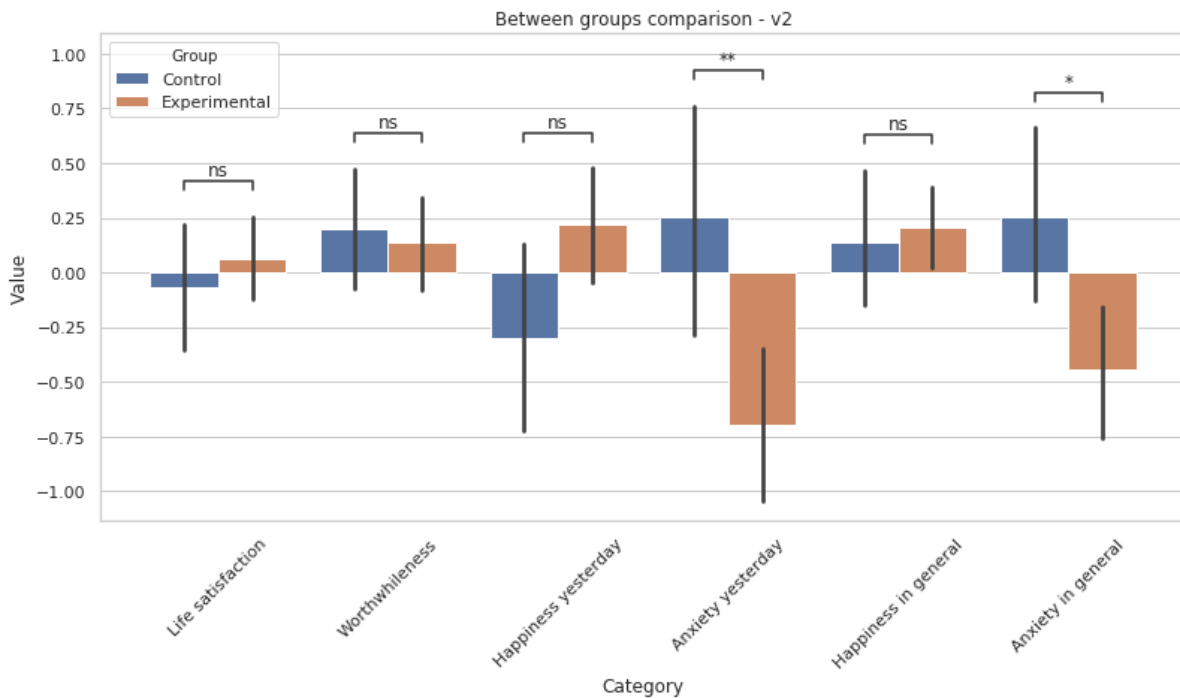
Figure 11: Change in well-being measure between onboarding and exit questionnaire for control (blue) and treatment (orange) groups in study 1. *: p < 0.05, **: p < 0.01.

The size of the improvement in anxiety *yesterday* due to the treatment is small to medium (Cohen's $d = 0.36$), while it is somewhat smaller for anxiety *in general* ($d = 0.30$). In addition, simple linear regressions show that in the treatment group, filling in more EMA or DRM questionnaires is significantly associated with greater reductions in anxiety between onboarding and exit surveys ($p < 0.001$ for anxiety *yesterday*, $p = 0.005$ for anxiety *in general*).

We further check whether participants with low versus high levels of each well-being measure differ in how they react to the treatment, but find no significant differences across our sample. In the case of reducing anxiety, this means that whether people start with high or low levels of anxiety does not influence how effective the treatment was.

Study 2

Using the same statistical approach as in study 1, we compare the difference between the well-being scores pre- and post-study in the control and treatment groups. As in study 1, we find no significant effects of the treatment on life satisfaction (diff. = 0.32, p = 0.109), worthwhileness (diff. = -0.11, p = 0.821), happiness *yesterday* (diff. = 0.54, p = 0.081) or happiness *in general* (diff. = 0.24, p = 0.177). Consistent with study 1, we find a significant effect of the treatment on anxiety (namely, anxiety *in general* diff. = -0.42, p = 0.037,

whereas anxiety *yesterday* was not significantly reduced diff. = -0.26, p = 0.606). Like in study 1, this reduction in anxiety is driven by a significant decrease in reported anxiety *in general* between the onboarding and the exit questionnaire (diff. = -0.50, p = 0.017), while the control group reported general anxiety levels that were not significantly different between the start and the end of the study (diff. = -0.08, p = 0.971).
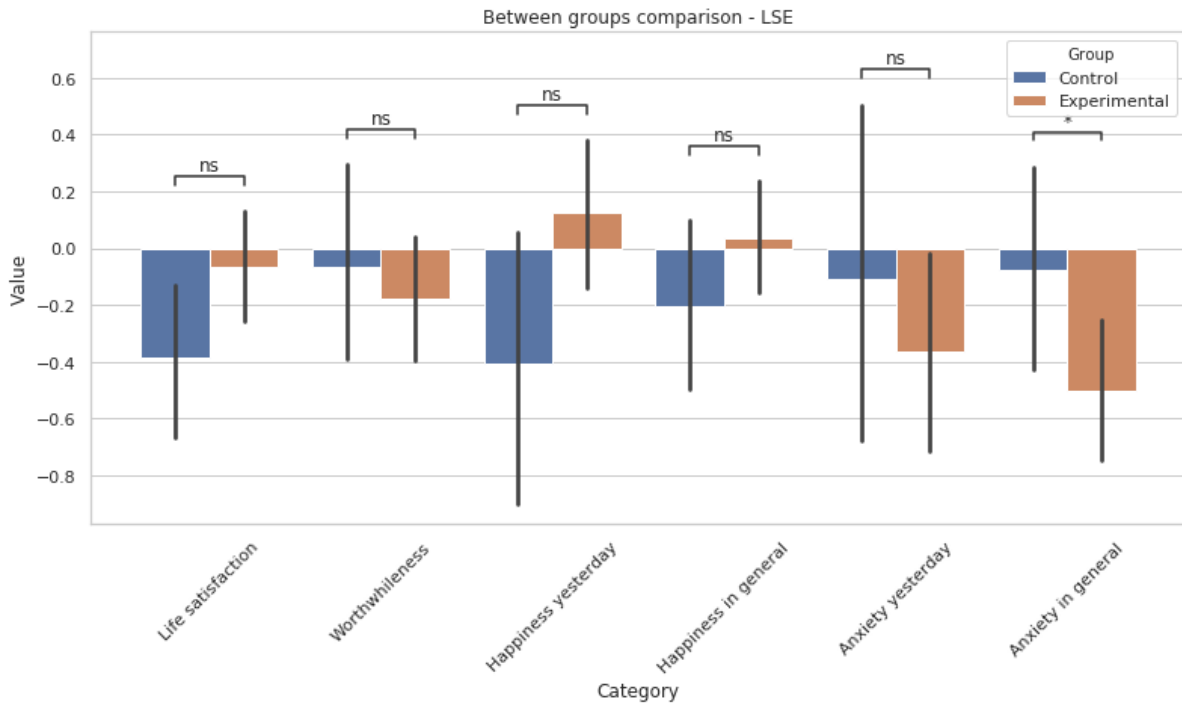
*Figure 12: Change in well-being measure between onboarding and exit questionnaire for control (blue) and treatment (orange) groups in study 2. *: p < 0.05.*

The Cohen's *d* indicates that the size of the improvement in anxiety *in general* resulting from the treatment is small (*d* = 0.18). Our simple linear regression once again shows that answering a higher number of EMA or DRM questionnaires was associated with greater reductions in anxiety in the treatment group (p = 0.001).

There are no treatment effects across life satisfaction, worthwhileness or happiness either depending on whether participants reported low versus high starting levels of the respective well-being measure. However, we find the significant effect of the treatment on anxiety *in general* in the sub-sample of participants who reported high starting levels of anxiety *in general* (diff. = -0.85, p = 0.002), but not among people who reported low starting levels (diff. = 0.13, p = 0.921). This suggests that the treatment was more effective at reducing anxiety *in general* among people who reported higher levels of anxiety at the start of the study.

Study 3

Using the same statistical approach as in studies 1 and 2, we find no significant effects from the treatment on any of the well-being questions reported in studies 1 and 2 after four weeks. We find no significant differences between treatment and control group for measures of stress (PSS-10, $p = 0.446$), depression (PHQ-8, $p = 0.169$), or well-being (WHO-5, $p = 0.715$). However, we find that the treatment caused a significant decrease in reports of anxiety (which was measured with GAD-7, a common screening tool and severity measure; diff. = -1.59, $p = 0.012$).
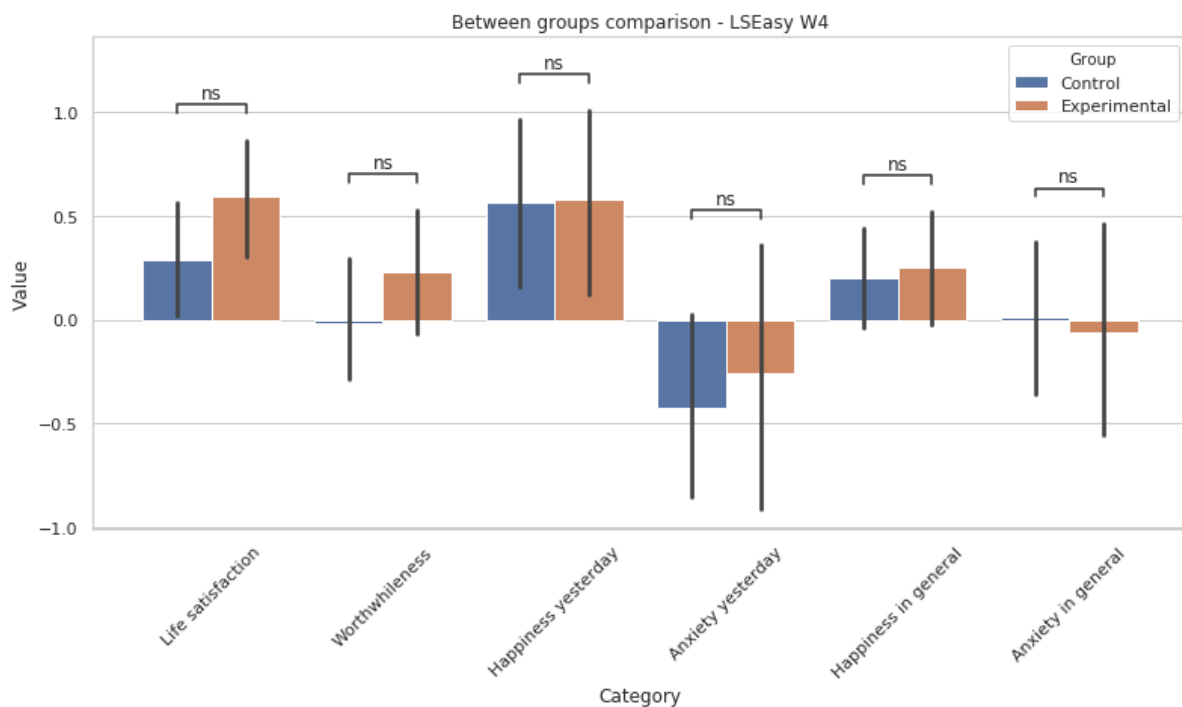
Figure 13 (part 1): Change in well-being measure between onboarding and exit questionnaire for control (blue) and treatment (orange) groups. *: p < 0.05.
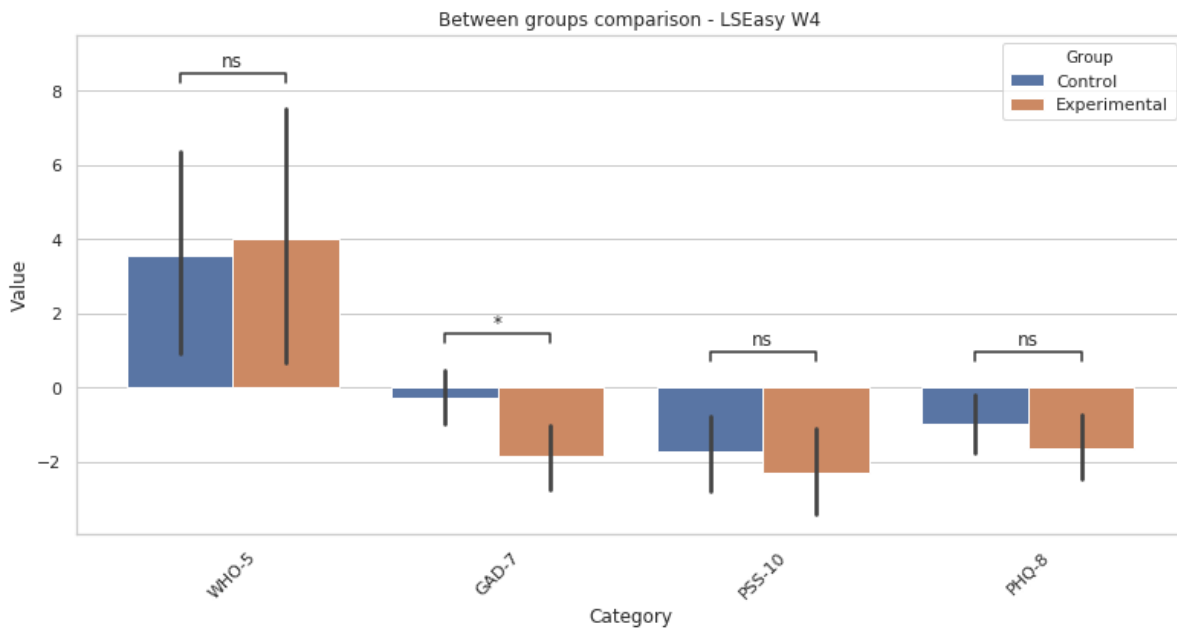
*Figure 14 (part 2): Change in well-being measure between onboarding and exit questionnaire for control (blue) and treatment (orange) groups. *: p < 0.05.*

This overall impact of the treatment on anxiety is of similar magnitude as the effect of the treatment that was reported on anxiety *in general* in study 1 ($d = 0.30$). As in studies 1 and 2, the significant effect of the treatment on anxiety in study 3 is driven by a significant decrease in reported anxiety scores between onboarding and exit questionnaires in the treatment group (diff. = -1.87, p = 0.027), and we find that filling in more DRM questionnaires throughout the study was associated with a significantly larger reduction in anxiety (p < 0.001). There was no significant decrease in anxiety reports in the control group (diff. = -0.28, p = 0.621).

Like in study 1, there are no significant differences in how the treatment affects mental well-being depending on whether participants reported high or low starting values.

Discussion

We assess the impact of reporting well-being, context, and thoughts using EMA and DRM questionnaires over the course of a few weeks on a range of mental well-being outcomes. We find that completing EMA and/or DRM questionnaires is consistently related to significant reductions in anxiety across both single-question and multiple-item measures, in all studies. Specifically, in studies 1 and 2, we find small to medium-sized effects of completing EMA and DRM questionnaires on reports of anxiety *yesterday* (only study 1) and anxiety *in general* (both studies) after three and two weeks, respectively. In study 3, we find a small effect of filling in DRM questionnaires for two weeks on anxiety (i.e., GAD-7 scores)

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reported two weeks after the end of the study. The effect sizes ($d = [0.18, 0.36]$) are comparable to the effects of behavioural interventions ($d = [0.22, 0.44]$; Weiss et al., 2016) or positive psychology interventions on subjective and psychological well-being ($d = [0.08, 0.43]$; Koydemir et al., 2021). This is particularly striking given that these measures were not designed to be well-being interventions. Reporting on well-being did not impact happiness, worthwhileness or life satisfaction, though it did trend towards improvements on all well-being and mental health indices, with the exception of worthwhileness.

Our work presents consistent evidence of the impact of reporting well-being, thoughts, and their context on anxiety – studies 1 and 2 used an active control group, whereby participants in the control group received a sham version of the EMA and DRM questionnaires, whilst a waitlist control group was used in study 3. The sham version asked participants to report what they were doing, who they were with and where they were, but not what they were thinking about or how they were feeling. Hence, the positive impact of completing these questionnaires can be attributed to the specific act of reporting contextual factors (i.e., activity, company, location), well-being and thoughts simultaneously, rather than merely reflecting on context.

The studies presented in this paper find beneficial effects of using EMA and DRM questionnaires on people's reported levels of anxiety across both clinical (GAD-7) and population survey (ONS-4) measures of anxiety, different timespans, and, most importantly, different social and cultural contexts. Indeed, the impact of answering EMA and DRM questionnaires on anxiety was captured first in a sample of working adults living in Spain and Spanish-speaking Latin American countries, then in a student sample in a UK university, suggesting that our findings may be generalisable across cultural contexts and occupations.

As per the inclusion criteria for this analysis (see methods section), all participants completed at least 5 DRM questionnaires throughout their participation. Completing more EMA and/or DRM questionnaires was consistently associated with greater reductions in the anxiety measures, suggesting that the impact of the intervention increases with more exposure, i.e., more reports. Furthermore, stronger anxiety reductions were found after three weeks in study 1 than after two weeks in study 2, suggesting also that the impact of reporting one's thoughts and well-being, especially on momentary measures of anxiety (i.e., anxiety yesterday), might develop over more extended periods of time. This is corroborated by the findings in study 3, where the impact on people's GAD-7 reports was found two weeks *after*

the end of the study, but not in the surveys that immediately followed the data collection and participant exposure to daily DRM questionnaires. Previous studies looking at the impacts of other well-being interventions have shown similar patterns of lagged improvements in clinical measures of mental health, suggesting that similar mechanisms may be at play here (Catuara-Solarz et al., 2021).

It is interesting that reporting well-being, thoughts and context leads to reductions in anxiety but not increases in happiness, worthwhileness, or life satisfaction. While it remains unclear why this type of intervention would reduce negative but not increase positive affect, this differential result is consistent with the large body of evidence supporting the independence of positive and negative affect (Diener & Emmons, 1984; Goldstein & Strube, 1994). More puzzling is the fact that completing DRM in study 3 reduced anxiety according to GAD-7 scores, but not depression (PHQ-8), as other studies have hinted at. Since both constructs are closely tied to negative affect and have a strong association with each other, one might expect interventions reducing anxiety to also reduce depression.

There are, however, some important factors on which anxiety and depression differ. Namely, anxiety appears to be future-oriented and directed towards people's internal worlds, while depression is past-oriented and related more to interpersonal aspects of reality (Kreitler, 2018; Pomerantz & Rose, 2014; Shipp & Aeon, 2019). Given that the process of reporting on well-being through EMA and DRM is inherently focused more on current (or recent) internal experiences, it may not be surprising that such reports would be more beneficial in terms of dealing with anxiety than depression. We may also expect that part of the beneficial impact of these reports comes from people being able to project themselves into the near future with more clarity, therefore reducing future-related negative affect through better affective forecasting (Wilson & Gilbert, 2005). Since the present moment is often factored into our predictions about the future, it is plausible that orientating people's attention to current, or recent, thoughts and feelings can help to produce more optimistic affective forecasts, thereby reducing anxiety. Alternatively, it may be that rather than altering their affective response, people alter their behaviour. While the present studies were not suited to test these potential mechanisms, future work could explore this by documenting people's motivations to change their affective and/or behavioural tendencies alongside frequent reporting of their contextualised well-being and thoughts.

Although some previous studies have found a direct impact of EMA reports on depression, the literature remains inconclusive as to whether EMA can be used as an intervention against depression. Studies using EMA as an accompaniment to other interventions (CBT and positive psychology) tend to report more consistent effects (Beames et al., 2021). Thus, it appears that whilst EMA show promise in reducing depression, this may require more than mere reporting of thoughts, well-being and their context. Depression treatment may instead require a more structured, person-facing, intervention, as well as deeper awareness levels. Nevertheless, given that anxiety commonly precedes depression (Fava et al., 2000), the type of intervention we present in this study could be considered a useful preventative tool against the onset of depression. Moreover, the relative ease of implementing a stand-alone digital intervention like this is great compared to more complex treatment methods like CBT (Wichers et al., 2011).

There are a couple of factors limiting the interpretation of our findings. Firstly, while our studies conclusively show that reporting well-being, thoughts and their context is an effective way to reduce anxiety, it is yet unclear which specific method (EMA or DRM) and which specific reports are the driving forces behind our findings. Since all studies used the same template for EMA and DRM questionnaires, it remains unclear whether what matters is the addition of reports of thoughts, well-being, both, or the interaction between those and the contextual variables. Building on this, future research should explore the relative contribution of these factors when considered in isolation, and in tandem with interventions that focus on different aspects of the reflection process, to see which processes are most effective at improving which facets of mental well-being.

As the studies presented in this paper differ widely in terms of social and cultural context, we cannot make claims regarding the effectiveness of one method compared to the other. While studies 1 and 2 were designed with the intention of assessing whether reporting one's thoughts and well-being improved well-being, and this hypothesis was preregistered for studies 2 and 3, all studies were conducted to test a wider range of hypotheses. As such, it was not feasible to design separate treatments in which people used only EMA or DRM, or where people answered only thought- or well-being-related questions, but future research should explore this possibility.

Secondly, we collected data for study 3 during the Covid-19 pandemic, while study 1 and 2 were conducted before the pandemic. While it is unclear how this difference in context

might have affected the way people reacted to completing DRM questionnaires, we know that the pandemic had a large impact on mental well-being in the UK and across the world (Helliwell et al., 2021; Lades et al., 2020; O'Connor et al., 2021). The unique social context of the pandemic may call into question how generalisable results from this time period are relative to "normal" times. As such, future research should consider replicating the findings of study 3 in a post-pandemic context.

Thirdly, the design of studies 1, 2 and 3 did not allow us to unpack the underpinning mechanisms that led to the observed reductions in anxiety. The act of reporting may draw people's attention to their feelings, their thoughts, and the context in which these are experienced, thereby improving their awareness of how they feel in certain situations and potentially encouraging some individuals to reflect on their day-to-day activities and well-being. However, although this may explain why repeatedly reporting well-being, thoughts, and context caused reductions in anxiety levels, we refrain from drawing firm conclusions. Further research is needed to understand to what extent reporting well-being and thoughts improves awareness or makes people reflect on these internal states and their external context. Nevertheless, this work extends current literature on well-being interventions by showing that identifying and contextualising thoughts and well-being states can work as a well-being enhancing intervention.

To conclude, asking people to report their well-being, thoughts, and contexts through EMA and DRM questionnaires, over periods of as little as two weeks, significantly reduces anxiety, and more frequent reports are associated with greater reductions in anxiety. Therefore, what have thus far been used as data collection tools may turn out to be powerful, low-cost interventions to improve people's mental well-being – to similar orders of magnitude as interventions that were designed specifically for that purpose. Indeed, reducing our anxiety may be as simple as taking a few minutes every day to report what we did, thought about and how we felt in different situations.

General discussion

Well-being research serves two intertwined purposes. First, it is an attempt to better understand the correlates and determinants of people's well-being. But this is only meaningful if it is coupled with a more practical purpose; that is, to use this improved understanding to design and test better well-being enhancing interventions. In order words, we seek to understand how people feel, and why they feel the way they do, so that we may create more effective tools to make them feel better.

In this thesis, we sought to contribute to both aspects of the growing body of well-being literature. In chapters 3 to 5, we expanded the current understanding of the relationship between thoughts and well-being, while discussing the practical implications and applications of our findings along the way. In chapter 6, we explored how the tools we used to collect our data might have improved our participants' well-being.

Below, we summarise the main findings of all studies and discuss how they jointly contribute to the literature by tying them back to the overarching model that we proposed in the theoretical framework (p. 17) of this thesis. We then discuss overarching limitations and directions for future research, as well as practical take-aways for researchers and practitioners looking to incorporate our findings in well-being enhancing interventions.

Thoughts and well-being

In chapters 3 to 5, we explored the relationship between thoughts and well-being over time and across individual differences and contexts. In doing so, we informed the model that was proposed in chapter 1, in which we suggest that thoughts are important direct predictors of well-being, but that this relationship is moderated by both external factors and individual-specific characteristics. Table 20 lists the main findings from each chapter.

	Findings
Chapter 3	• TUT are not associated with significantly lower happiness when we account for the content of thoughts. However, they are associated with significantly lower worthwhileness irrespective of content of thoughts. • Content of thoughts is predictive of experienced happiness, but not worthwhileness. • Valence is the strongest predictor of well-being, but positive and negative TUT predict well-being less strongly (in significance and magnitude) than positive and negative TCA.

	• Lagged models show that negative and neutral thoughts at t-1 predict both happiness and worthwhileness at t. Positive thoughts at t-1 do not significantly predict either.
	• Past-related thoughts at t-1 are associated with significantly lower happiness at t.
	• Fixed effect regressions including thoughts predict well-being better than models including activities.
	• Thoughts predict happiness better than worthwhileness.
Chapter 4	• Personality traits do not significantly predict the occurrence of TUT, or the occurrence of certain contents of thoughts (others- and past-related).
	• Future- and self-related thoughts are significantly predicted by openness to experience and emotional stability.
	• Valence of thoughts is significantly predicted by extroversion (only positive thoughts), conscientiousness and emotional stability (positive and negative thoughts). Associations with positive thoughts are all positive; associations with negative thoughts are negative.
	• Conscientiousness, extroversion and emotional stability significantly predict experienced happiness and worthwhileness.
	• Random slopes in the multi-level models show that both happiness and worthwhileness are better explained when taking into account individual-specific variations in how people react to type and content of thoughts.
	• Self-reported personality traits are unable to explain this individual-specific variation when predicting experienced happiness.
	• Openness to experience moderates the relationship between TUT, others-related thoughts and experienced worthwhileness. Agreeableness moderates the relationship between others-related thoughts and worthwhileness.
Chapter 5	• People report significantly more TUT during activities that are less cognitively demanding (e.g., eating/drinking, commuting, as opposed to working or studying).
	• They also report more TUT when they are around people that they are more familiar with (e.g., partner or family, as opposed to strangers or colleagues).
	• Proportions of reported positive and negative thoughts also vary depending on the activity and the company that people report. This is not the case for content of thoughts.
	• Type and valence of thoughts do not predict experienced happiness differently across different activities. There are only small differences in terms of how people experience content.
	• There are more substantial differences in how thoughts are associated to experienced happiness depending on who people are with. Specifically, people experience significantly higher levels of happiness when they report TUT when they are with their partner.
	• Past- and self-related thoughts are associated with significantly lower happiness when people are alone.
	• The relationship between TUT and experienced worthwhileness is negative and significant in the general model (as seen in chapter 3), but this relationship is only significant when people are studying, alone or

	with friends. The relationship between TUT and experienced worthwhileness is significant and positive when people are with family.

Table 20: Summary of the main findings of chapters 3 to 5, relating to the relationship between thoughts and well-being.

Distinction between happiness and worthwhileness

Our first distinct contribution is to show that the direct relationship between thoughts and well-being is different for experienced happiness and experienced worthwhileness. This finding was echoed throughout the analysis of all three chapters. Particularly striking is the fact that personality traits in our dataset predicted happiness and worthwhileness in similar ways (see chapter 4), but that the relationship between thoughts and well-being was unique to each construct. Specifically, the type of thought appears to be more important for worthwhileness, while it is the content of TUT that better predicts happiness. Figure 15 illustrates this difference in terms of the questions people are asked to answer when reporting thoughts.
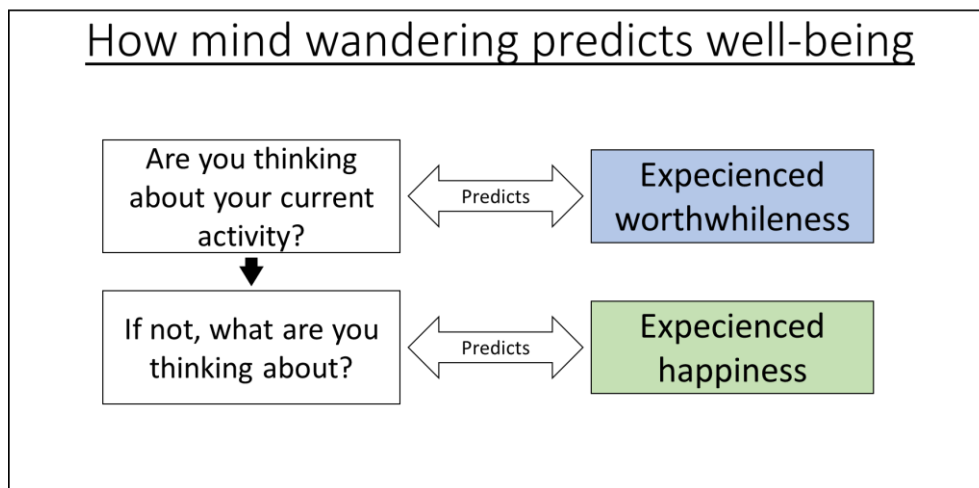
Figure 15: Illustration of how mind wandering predicts well-being in terms of experienced happiness and experienced worthwhileness.

This has interesting implications for the literature on mind wandering in general. Indeed, while the literature had previously considered that different measures and levels of precision in capturing thoughts might matter in terms of predicting well-being (Andrews-Hanna et al., 2013; Blouin-Hudon & Zelenski, 2016; Killingsworth & Gilbert, 2010), it had not, to date, considered the possibility that different levels of precision might be better suited to different measures of well-being.

In chapter 5 (p. 109), however, we found that in fact, TUT only significantly predicted experienced worthwhileness when participants reported to be studying, which was the most

commonly reported activity in our data, as our sample was composed of students. However, the signs of the TUT coefficient in the other activities (e.g., negative for working, positive for commuting) may hint at one of the mechanisms driving the relationship between thoughts and worthwhileness.

We know from previous literature that some activities are inherently more purposeful than others (White & Dolan, 2009). This is the case for activities like studying or working, and we might expect that in such activities, how much attention we pay to what we are doing should be directly related to the levels of experienced worthwhileness that we report. It is then the awareness of how worthwhile the activity *is supposed to be* that would drive how worthwhile TUT are perceived to be, thus explaining why the content of TUT matters less. In such situations, the *attentional failure hypothesis* that was discussed in chapter 1 (p. 35) might explain both the negative association between TUT and worthwhileness and why people still report TUT in these activities despite the existence of this negative association (see also, Lee & Chao, 2012; Toh & Yang, 2022). Figure 16 shows how the attentional failure hypothesis might apply in such situations.
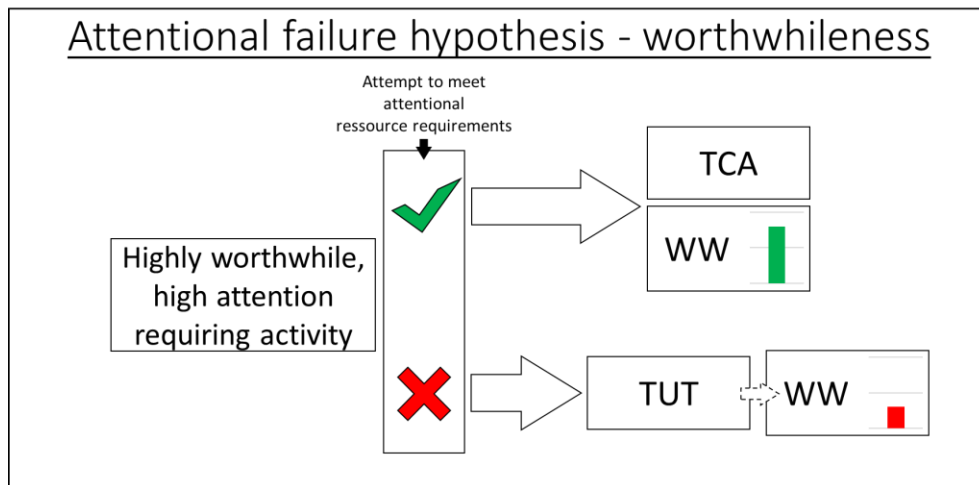
Figure 16: Illustration of the attentional failure mechanism that might explain the negative association between TUT and worthwhileness for highly worthwhile, high attention requiring activities. (WW = worthwhileness).

The fact that people experience significantly less TUT during activities like working and studying, despite the fact that these are obviously more cognitively demanding than activities like commuting, social media or eating and drinking, supports this idea.

This mechanism makes no prediction regarding what happens to the relationship between TUT and worthwhileness in activities that are perceived as less worthwhile or that

are less attention demanding. We may expect, however, that during activities that are perceived as particularly low in worthwhileness, TUT might actually be positively related to experienced worthwhileness, although the sub-samples for activities like commuting, which might fall into this category, were not sufficiently powered to reveal significant associations. For low attention-demanding activities, we may expect that the relationship between TUT and experienced worthwhileness would be neutral, or determined by other unrelated factors, as the low attention demands of the activity would allow for people's minds to wander regardless of how they perceive the activity in the first place.

While our findings do not rule out the possibility that the attentional failure hypothesis also explains the relationship between TUT and happiness in some contexts, they do not allow us to make any inferences in this regard. Instead, the associations between content of thoughts and happiness hint at what Smallwood and Andrews-Hanna (2013) already described in the *content-regulation hypothesis*, whereby people react differently to their thoughts depending on their content (p. 36). We address this in more detail when discussing the implications of our findings for the *content-* and *context-regulation hypotheses*, below.

Overall, the findings in chapters 3 to 5 show that, while happiness and worthwhileness reports tend to be highly correlated, they are clearly distinct constructs, which further stresses the importance of considering both the hedonic and eudemonic components of well-being when studying mind wandering. We show that their relationship with thoughts is likely to be driven by different mechanisms, and we argue that some of these mechanisms may be driven by people's perception of what ought to make an experience happy or worthwhile.

The importance of valence of thoughts

We further contribute to the literature by showing just how important the valence of thoughts is in predicting well-being. In chapter 3, we discussed valence as an overarching feature of thoughts, which no previous paper that we are aware of has done. This is important, as we find that valence of TUT is differently associated to well-being than valence of TCA, where the valence of TUT appears to be less strongly associated to well-being than the valence of TCA (p. 61-63). In addition, our lagged analysis in the same chapter revealed that negative thoughts in general seemed to have a longer-lasting impact on people's well-being that positive thoughts (p. 66; see also, Diener et al., 2009).

In chapter 4, we found that the relationship between valence of thoughts and well-being may not be dependent on individual-specific characteristics, unlike the relationship between type and content of thoughts and well-being (p. 90). And finally, in chapter 5, we show that the relationship between valence of thoughts and well-being is the only relationship that remains consistent across all types of activities and company (p. 107-108).

Taken together, these findings indicate that valence of thoughts may be a crucial aspect of thoughts for intervention designers to focus on. While we found no consistent evidence that people share the same experience of specific types or contents of thoughts, we can say with reasonable confidence that we know how the valence of people's thoughts relates to their well-being (see also, Blouin-Hudon & Zelenski, 2016; Schooler et al., 2014). The causal link we find between negative thoughts and both happiness and worthwhileness suggests that targeting the valence of people's thoughts may be a simple and powerful intervention to explore.

It is also interesting to consider that while the association between positive thoughts and well-being appears to mirror that of negative thoughts, this is, in fact, not the case overtime, as positive thoughts do not have repercussions on well-being later, as negative thoughts do (p. 66). Just as positive and negative affect are highly correlated, but distinct constructs, our findings may imply that positive and negative thoughts are not merely two faces of the same coin (see also, Luhmann et al., 2014a). This begs the question of whether valence of thoughts may be better captured in a more nuanced way, and what the implications of that would be.

Adaptive mind wandering?

Previous studies have already hinted at the adaptive qualities of mind wandering (Baars, 2010; Mooneyham & Schooler, 2013; Poerio & Smallwood, 2016; Song & Wang, 2012), but less so in the context of well-being. In chapter 1, we suggested that TUT might be an adaptive reaction to negative activities, whereby people would seek to avoid the lowest levels of well-being associated to such activities by letting their mind wander, either consciously or subconsciously. We labelled this the *experience dampener hypothesis* (p. 34). From our models looking at the predictive power of activities on experienced happiness and worthwhileness (see Appendix A2), we note that few activities can be said to be unambiguously positive or negative, as there are frequently trade-offs between pleasure and purpose, and possibly other unobserved well-being indicators. This distinction would

therefore depend more on the individual and on the context, making it difficult to show conclusive evidence of the *experience dampener hypothesis* in day-to-day settings like in the present thesis.

Of the activities that were explored in chapter 5, only two negatively affected both well-being measures relative to the other activities in our sample (i.e., commuting and social media), and TUT were significant predictors of neither happiness nor worthwhileness in either of these activities. Unlike previous literature (Nyklíček et al., 2021), we elected against grouping the activities that participants reported into broader categories of valence, because we estimated that the empirical foundations of this practice were not convincing enough to attempt such a categorisation without making it the subject of an entirely separate research paper. As such, we take the view that whether an activity is perceived as positive or negative is itself context-specific and dependent on the individual.

However, while we do not have a perfect proxy for the valence of the activity, it seems plausible that the valence of TCA might be, at least to some extent, reflective of how people perceive the activity that they are engaged in, and we may use this to make some inferences regarding the *experience dampener hypothesis*. As discussed above, our analysis of valence of TCA and valence of TUT in chapter 3 showed that while the signs of the coefficients remain consistent across types of thoughts, the magnitude of these coefficients is consistently lower for TUT than it is for TCA. In other words, the positive association between positive TCA and well-being is stronger than the one between positive TUT and well-being. The same is true for negative TCA versus negative TUT.

This finding supports the intuition that TUT might acts as dampeners of emotional experiences. In other words, being mentally disconnected from the current activity might be associated with less extreme (positive or negative) experiences of well-being. This might explain why positive TCA appear to be associated with comparatively higher well-being than positive TUT, while negative TCA appear to be associated with lower well-being than negative TUT.

It seems plausible that people might instinctively seek higher states of well-being by reverting to TUT more frequently when they are engaged in negative activities, as opposed to pleasant or purposeful ones. As such, people may *adaptively* try to move away from negative TCA, when possible, even if the alternative TUT is also negative. This, of course, does not prevent people from sometimes reporting (negative) TUT during positive activities, for

instance through mechanisms like the attentional failure hypothesis. Figure 17 shows how the *experience dampener hypothesis* might apply here.
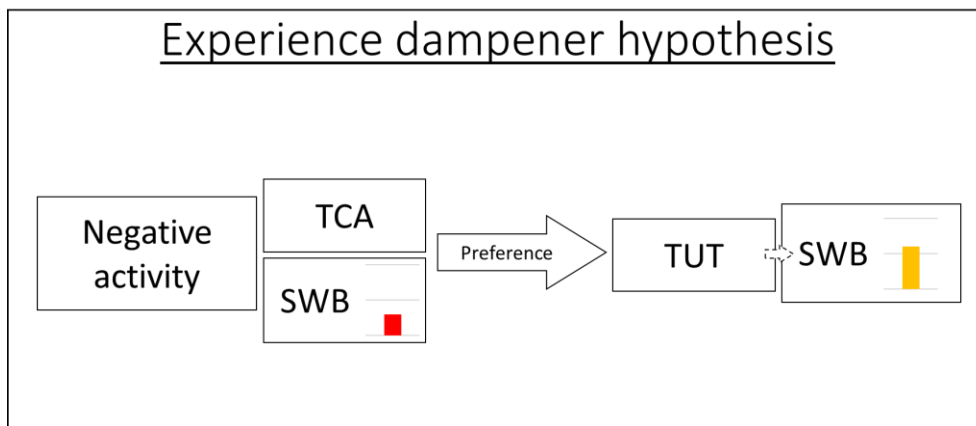
Figure 17: Illustration of the experience dampener mechanism that people might use to avoid negative TCA.

That being said, the evidence we present throughout this thesis is not enough to draw clear conclusions regarding the *experience dampener hypothesis*. For one, it is unclear to what extent mind wandering would be deliberate, as opposed to subconscious, in situations where it might be adaptive to think of something other than the current activity. Previous research has discussed the intentionality of mind wandering (e.g., Seli et al., 2016, 2017), and incorporating such measures might be helpful to better understand the extent to which people are able to deliberately seek the adaptive benefits of mind wandering. While the findings discussed above point towards the existence of meaningful relationships between thoughts and well-being, there are certainly many competing mechanisms at play. Disentangling these mechanisms may be difficult to do in ecologically valid but uncontrolled settings like we attempted to do in this thesis.

Content- and context-regulation hypotheses

The adaptive qualities of mind wandering have perhaps most prominently been suggested in Smallwood and Andrews-Hanna's (2013) *content-* and *context-regulation hypotheses*. The evidence we discuss in the present thesis confirms and expands on both of these hypotheses.

The *context-regulation hypothesis* states that people adaptively regulate how much they allow their mind to wander depending on the context of the task that they are engaged in. It specifically highlights that (1) people will experience more TUT in less attention-demanding tasks, (2) TUT will be associated with different costs and benefits depending on

the context in which they occur, and (3) people with different characteristics (in this case, cognitive capacity) will experience greater costs or benefits from TUT. This hypothesis was originally framed as a methodological one, suggesting that researchers should be mindful about the context that they create in their experiments. In the present thesis, we are able to confirm that this hypothesis also applies to ecologically valid contexts, and we provide evidence that suggests the *context-regulation hypothesis* can be extended to other aspects of context (p. 110-114).

Firstly, we show that people do indeed report less TUT during activities that are more attention demanding, and vice-versa (p. 103-105), suggesting that the lab evidence that this hypothesis is based on (see also, Kane & McVay, 2012; Randall et al., 2014) describes a phenomenon that is observable in people's day-to-day lives as well. Second, we show that TUT are indeed associated with significantly different levels of well-being depending on the context, which complements previous findings on the other possible costs and benefits associated with mind wandering in different contexts (Mooneyham & Schooler, 2013; Schooler et al., 2014; Smallwood & Schooler, 2015). Thirdly, we show that people with different individual-specific characteristics do indeed show different associations between TUT and well-being (p. 83). While our exploration of the Big 5 personality traits did not reveal very clear patterns in these associations, our findings point towards the validity of this component of the *context-regulation hypothesis* in the context of people's day-to-day well-being as well, and we encourage further research to look into different individual-specific characteristics that might be driving these differences (e.g., cognitive capacity, Rummel & Boywitt, 2014; trait mindfulness, Cardaciotto et al., 2008).

In addition, we are able to expand on the predictions made by the *context-regulation hypothesis* by extending our analysis of context beyond just tasks or activities. Our findings also suggest that people regulate how often their mind wanders depending on who they are with, and that this also matters in terms of the relationship between their thoughts and their well-being. As a result, we propose a set of updated predictions relating to the *context-regulation hypothesis* that goes beyond the methodological concerns of how researchers design their experiments, and that incorporates a broader perspective on context. These updated predictions are summarised in table 21 below.

Smallwood & Andrews-Hanna, 2013	Updated hypothesis

- People experience more mind wandering in less attention-demanding tasks, and vice-versa. - Mind wandering is associated with different costs and benefits, depending on the context in which it occurs. - People with greater cognitive capacity will derive less costs and more benefits from mind wandering in more attention-demanding tasks.	- People experience more mind wandering in less attention-demanding tasks and day-to-day activities, and vice-versa. - People experience more mind wandering when they are surrounded by people they are more familiar with, and vice versa. - Mind-wandering is associated with different costs and benefits, depending on the context in which it occurs (including, but not limited to, their activity, or task, and their company). - The costs and benefits that people derive from mind wandering will depend on a range of individual-specific characteristics, such as cognitive capacity, personality, and potentially other cognitive and socio-cultural characteristics.

Table 21: Updated predictions from the context-regulation hypothesis.

In addition, we argue that the context that a thought occurs in ought to be considered from a cognitive perspective, which has been the main consideration in the literature up to this point, but also from an emotional perspective (p. 112). When talking about the emotional dimension of context, we are not merely talking about the valence of the activity, as Nyklíček and colleagues (2021) attempted to do. Rather, we are acknowledging that the context of a thought extends beyond the cognitive characteristics of the activity, and that this context may be associated to a range of feelings that may be different from merely "how people feel". In chapter 5, we highlight the familiarity and comfort associated with the presence of others as a potentially important emotional dimension of context. While this emotional dimension of context is likely to impact how people feel, it is not a direct indicator of well-being. As such, future research should explore how separate measures can be designed to capture the emotional dimension of context rather than relying on the well-being indicators themselves to infer how participants perceive their context.

The *content-regulation hypothesis* states that people will adaptively seek to regulate the content of their mind wandering to maximise productive outcomes and minimise negative consequences for their well-being. It specifically points out that (1) future-related TUT may be beneficial as they allow people to plan ahead, (2) past-related TUT will tend to be associated with negative well-being outcomes, and (3) the costs and benefits of certain contents of TUT will also depend on the situation in which they occur. The more explicit framing of this hypothesis in terms of well-being allows us to directly compare its predictions to the findings we report in this thesis.

Firstly, while we do not find evidence that future-related thoughts are associated with higher levels of well-being, we do find that the interaction between self- and future-related thoughts tends to be associated with higher well-being than thoughts that are only self- or future-related (p. 61-62). While this does not conclusively show that the first prediction of the *content-regulation hypothesis* holds in ecologically valid settings, it indicates that there might be an adaptive quality to certain kinds of future-related thoughts, which broadly supports the *content-regulation hypothesis* in general. Secondly, we confirm the intuition that past-related thoughts tend to be associated with lower well-being, and even that they can be said to cause lower experienced happiness, according to our time-lag analysis in chapter 3 (p. 66; see also, Ruby et al., 2013). Thirdly, we show that the association between content of TUT and well-being does indeed differ depending on the situation.

We also build on the predictions made by the *content-regulation hypothesis* by showing that self-related thoughts can be beneficial in some contexts (e.g., when socialising or with colleagues) and detrimental in others (e.g., when alone; p. 106-108). More generally, we looked at two dimensions of content of thoughts – a social and a temporal one –, both of which were shown to be associated to well-being measures in some contexts.

Smallwood & Andrews-Hanna, 2013	Updated hypothesis
• Future-related mind wandering allows people to plan ahead. • Past-related mind wandering is negatively associated with well-being. • The costs and benefits of specific contents of mind wandering depend on the situation.	• Future-related mind wandering allows people to plan ahead, but can be detrimental to people's well-being when it is not associated to the self. • Past-related mind wandering is negatively associated with well-being.

	• The costs and benefits of specific contents of mind wandering depend on the situation.
	• Self-related mind wandering is associated with lower well-being when people are alone.
	• The social content of mind wandering is also associated to well-being in different contexts.

Table 22: Updated predictions from the content-regulation hypothesis.

In addition, we echo Smallwood and Andrews-Hanna's (2013) suggestions regarding the implications of the *content-regulation hypothesis*. Indeed, they argue that well-being enhancing interventions should not be designed to avoid TUT altogether, but rather that they should incorporate the growing understanding of which contents of mind wandering are beneficial, and which are detrimental to well-being, in order to provide people with more targeted, more effective interventions (see also, Franklin et al., 2013). We elaborate on these implications further when discussing contributions to the well-being intervention literature later in this General discussion.

Overarching model of well-being

We also contribute to the general well-being literature, as we show that thoughts better predict well-being than activities, thus confirming the importance of incorporating thoughts into general models predicting well-being. The model we propose to build upon the existing literature incorporates thoughts as an essential determinant of well-being, alongside individual-specific characteristics and context (see also, p.18).

In chapter 3, we showed that thoughts are directly predictive of well-being, but also that some components of thoughts can be said to cause well-being. In chapter 4, we showed that the direct relationship between thoughts and well-being is moderated by personality and other unobserved individual-specific characteristics. In chapter 5, we showed that the relationship between thoughts and well-being differs depending on two contextual factors, i.e., the activity that people are engaged in and the company that they report. In the process, we also showed that some components of thoughts are predicted by personality and these

contextual variables too. Figure 18 shows a high-level breakdown of the model that incorporates these findings.
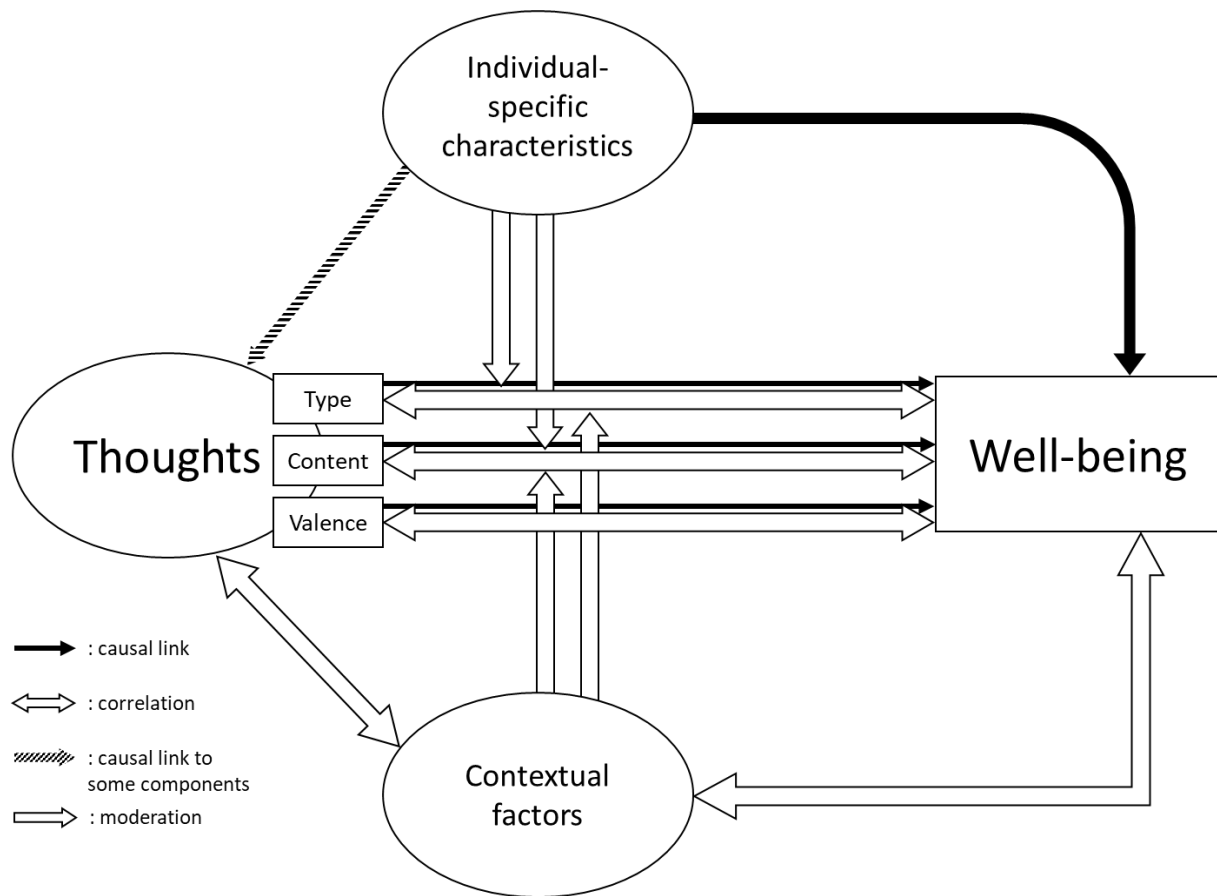
Figure 18: Overview of the findings from this thesis incorporated in the overarching thoughts model of well-being.

While the findings we report can only provide an incomplete picture of the relationships that are captured by the model, they can be used as a starting point for further research looking to further imbed thoughts into models predicting well-being. In particular, our findings in chapter 4 revealed that most of the individual-specific variations in the relationship between thoughts and well-being were unobserved (p. 88). While we explored how other scale-based personality traits (i.e., self-esteem, optimism, attitude towards uncertainty, locus of control) might have moderated the relationship between thoughts and well-being in the Appendix (see Appendix A3), these models did not provide any more conclusive findings. Particularly relating this back to the existing literature and to the *context-regulation hypothesis* as described above, it may be interesting to consider individual-specific characteristics that are known to predict mind wandering, like working memory capacity or attention control (see also, Robison et al., 2020). Cultural characteristics provide another possible avenue in this regard, as previous research had already shown that the content of

people's thoughts differs quite substantially depending on their first language alone (Martinon et al., 2019).

The same holds for our exploration of contextual factors. While chapter 5 provided evidence that context matters, we were constrained by the specific contexts that were most reported by our participants for the purpose of our analyses. As it happens, these contexts, especially in terms of the specific activities that we considered, were not the ones that previous research had most frequently related to mind wandering. As such, studies expanding the pool of considered activities to things like exercise, reading, meditation, or other more studied activities (e.g., Feng et al., 2013; Jazaieri et al., 2016; Latinjak, 2018) might further inform how exactly the relationship between thoughts and well-being is affected by context. We can also imagine that other types of contexts played an important role, both in terms of how they might predict thoughts and how they influence the relationship between thoughts and well-being. For example, weather and temperature might have been important unobserved pieces of context (e.g., Keller et al., 2005; Denissen et al., 2008).

Finally, as was stressed in the discussion of chapters 3 to 5 already, there are many more components of thoughts that might be worth incorporating in the study of how thoughts relate to well-being, and these components of thoughts are likely to matter in terms of completing our suggested model. Such components include, for example, intentionality of mind wandering (e.g., Seli et al., 2016, 2017), or vividness (e.g., Mar et al., 2012), which could easily be captured through self-reports in the same way that we captured content and valence of thoughts in this thesis.

Well-being interventions

Besides the literature on the relationship between thoughts and well-being, we contribute to the literature on well-being interventions in two main ways: (1) by providing evidence on what aspects of the relationship between thoughts and well-being to focus on in the design of well-being enhancing interventions, and (2) by showing that our data collection procedure used in chapters 3 to 5 can function as a simple, low-cost well-being enhancing intervention. In the sub-sections below, we discuss the practical take-aways from the findings we report in chapters 3 to 6, and we give some recommendations for the design of well-being enhancing interventions.

Practical take-aways

With the rise of mindfulness as a research and social interest, thought-related interventions have been popular, particularly in the domain of self-help mobile apps (Schultchen et al., 2021; Mani et al., 2015). But even though the notion that all mind wandering is detrimental to our well-being has long been challenged in academic circles, it seems that much of these popular self-help tools are still based on eliminating any kind of mind wandering to focus on the present moment. While this has been shown to have positive effects on well-being in certain situations, evidence is also starting to emerge showing that not everyone is benefiting from such practices (Kaufmann et al., 2021; Van Dam et al., 2018).

Instead, the recommendation from the mind wandering literature has been to focus on deepening our understanding of which thoughts are more or less beneficial to people, and to design interventions that help people differentiate between the thoughts that affect them positively and the ones that affect them negatively (Franklin et al., 2013; Smallwood & Andrews-Hanna, 2013). In the present thesis, we identified some specific thoughts that interventions could be designed around. Echoing the past literature, we found that negative thoughts have a lasting impact on both experienced happiness and worthwhileness. In addition, we found that past-related thoughts had lasting negative repercussions on happiness.

Therefore, our first practical take-away from these findings is that interventions that focus on people's thoughts should focus specifically on helping people avoid negative and past-related thoughts. Notably, the past was the only content of TUT that had such negative repercussions on well-being, suggesting that there is little use in asking people to avoid mind wandering altogether.

As far as valence is concerned, the negative association between negative thoughts and well-being persists over time, while the positive association between positive thoughts and well-being is only observed in the moment. As such, we argue specifically in favour of intervention that focus on the reduction of negative thoughts, as opposed to interventions that merely try to foster positive ones, as the former should have longer-lasting impacts on well-being.

Our next practical take-away is about the importance of context and personalisation. Much of the literature on mobile apps argues that there is a need for more personalisation of these apps to better cater to the needs of each individual (Stawarz et al., 2019; Woodward et

al., 2020). However, when it comes to thoughts, we were unable to definitively isolate any individual-specific characteristic that might actually be used to customise the interventions offered by these apps. While our findings suggest that empirically informed personalisation might indeed improve the effectiveness of thought-related interventions, we are unable to provide guidelines regarding what individual-specific characteristics interventions designers should use for this personalisation.

As the rest of the current literature does not provide any clear recommendations in terms of how to personalise thought-related interventions either, we suggest that designers of well-being interventions focus on the context in which people experience their thoughts instead. Indeed, our findings show that there are clear contexts in which mind wandering is desirable (e.g., with one's partner) or undesirable (e.g., when studying), and we see that certain contents of thoughts (particularly, social content) are associated with substantial variations in well-being during certain activities or in certain company. While more research is necessary to establish a robust-enough empirical foundation to inform actual interventions, context-specific interventions might be a more feasible alternative than personalised ones, at least when it comes to incorporating thoughts in such interventions.

Simple vs complex interventions

An important trade-off in the design of well-being interventions, especially mobile self-help tools, is between the complexity and the efficiency of the intervention. Indeed, while clinical psychologists have developed very effective, complex tools to deal with mental health and improve well-being, such as Cognitive Behavioural Therapy (CBT; Cuijpers et al., 2013; Sheldon, 2011), the incorporation of such complex interventions has not always translated into the same level of effectiveness in mobile self-help formats (Lan et al., 2018; Wright et al., 2019). This begs the question of what designers of mobile interventions should favour.

In chapter 6, we showed that the tools we used to gather the data for chapters 3 to 5, among others, can serve as an anxiety-reducing intervention that shows the same magnitude of effects as mobile versions of much more complex interventions (e.g., behavioural or positive psychology interventions; Koydemir et al., 2021; Weiss et al., 2016). As a result, we suggest that the complexity of the interventions that are provided through self-help tools may not necessarily be reflective of their effectiveness, and that simple questionnaires that draw

people's attention to some of their internal processes may be just as powerful to improve their overall well-being.

While the data used in chapter 6 did not allow us to infer what mechanisms were triggered by the questions that we asked participants, we can imagine that repeatedly asking people about their activities, company, thoughts and well-being made them reflect more on their day-to-day thoughts and feelings, and how these are related to the context in which they are experienced. Such reflections may lead to higher levels of well-being (as suggested by previous literature; e.g., Adair et al., 2020; Lekes et al., 2012). If simple interventions can trigger such mechanisms, as appears to be the case for anxiety in chapter 6, simplicity should be favoured over complex interventions, making the design of such interventions both relatively costless and very easy to implement.

Chapter 6 does not allow us to draw similar conclusions for any other well-being or mental health indices, but it may serve as a cautionary tale for intervention designers. Indeed, it may be that there exist similarly simple interventions to improve people's happiness, or worthwhileness, or reduce their depression. While more experimentation is needed, our findings spur us to recommend intervention designers to consider simple, straightforward interventions over complex ones. If our intuition that our questionnaires triggered reflections in our participants is correct, the key to other well-being enhancing interventions may be to figure out how to trigger similar internal processes that stimulate improvements in other well-being measures.

Additional conceptual considerations

Aside from the implications for the literature and for practical interventions that were discussed above, the findings that we reported across chapters 3 to 6 also raise some deeper conceptual questions about the measures that we employed throughout this thesis. Below, we briefly discuss these conceptual considerations in relation to the well-being questions and the thought prompts that were used to collect the data.

Well-being questions

One of the assumptions underlying subjective measures of well-being is that, even though there are between-subject differences in how people understand questions like "how happy are you right now?", the within-subject understanding of what that question asks remains stable overtime (see also, Ingelström & Van der Deijl, 2021; Kristoffersen, 2010). In other words: if we ask one participant how happy they feel at the moment, and we ask them

the same question again tomorrow, or next week, or in a different context, that participant's interpretation of "happiness" and of the associated scale will be the same across every measurement.

However, in our exploration of the relationship between thoughts and well-being, and particularly distinguishing between different contexts in chapter 5, we discussed mechanisms that might suggest that this fundamental assumption is sometimes violated. When hypothesising about the existence of an emotional dimension to context that may drive both reports of thoughts and the relationship between thoughts and well-being (see p. 112), we also allude to the idea that certain terminologies of well-being may mean different things to the same person in different contexts. In particular, it raises the question of whether the same person always perceives "happiness" in the same way, depending on the context and on the specific internal experiences that they describe (see also, Angner, 2013; Ingelström & Van der Deijl, 2021).

In chapter 1, we discussed using "happiness" as a single-item proxy for positive affect (p. 24). The term "happiness" has the advantage of capturing a very general, positive internal experience. However, if different contexts are associated with different emotional undertones (related to comfort, familiarity, or any number of other sensations), it is inevitable that beyond the distinction of whether the experience is positive or negative, people also experience vastly different types and intensities of feelings (in the case of positive affect; contentment, joy, excitement, etc.). In practice, this means that when people are answering the question "how happy do you feel right now?", they have to assign a one-dimensional score to a multi-faceted experience (see also, Egloff et al., 2003; Gilbert et al., 2008; Stanton & Watson, 2015). What does it mean, then, if someone rates their experience an 8 when they feel calm and content, but also when they are bustling with excitement? Are these two experiences comparable? Do people subconsciously trade off these different situations when making the assessment, or does each assessment focus only on the momentary feeling independently of all the other possible forms of happiness that they might experience?

While it is beyond the scope of this thesis to answer these questions, they may have important implications for the design of experience sampling studies. The nature of experience sampling questionnaires requires them to be short and simple to complete. As a result, researchers may favour general proxies to measure well-being over questions related to more specific emotions. This, however, may come at the cost of capturing precisely what

people are actually feeling. Future research may benefit from exploring the use of multi-item measures of well-being (e.g., PANAS, SPANE; Diener et al., 2010; Watson et al., 1988) to get a better sense of which specific emotions people are experiencing in different contexts, and of how these feed into the rating of general measures like "happiness".

In exploring the relationship between thoughts and well-being, there are no studies (that we are aware of) looking at such precise ranges of emotions. In the present thesis, we found that there were very few contexts in which TUT predicted experienced happiness. Another possible explanation for this finding could be that TUT relate differently to more specific emotions that we did not capture in our data. The same is true for the impact of well-being enhancing interventions, which could turn out to affect specific emotional experiences more than others, as our findings in chapter 6 also hint at. These nuances may be lost when considering only general descriptors of well-being.

Thought questions

In chapter 4, we discussed the possibility that similar criticisms to the ones raised above may apply to our measures of thought. Indeed, we argue that, while the social and temporal categorisations of thoughts are useful to quantify the relationship between thoughts and well-being more precisely, these categorisations are currently limited by the fact that they group together very different thoughts. For example, we argued that what is meant by thoughts "about the past", or "about others", is specific to what part of the past, or which specific people, these thoughts are actually directed towards, and that these differences may in part be captured by unobserved individual-specific differences (p. 89).

However, it is equally possible that these differences are driven by the context in which the thought occurs. Presently, we have no way to analyse these nuances, as the answer options that we provided to our participants remain very high-level in terms of how they describe the content of their thoughts. Qualitative studies of mind wandering and its impact on various indicators exist (e.g., Burdett et al., 2018; Latinjak, 2018), however, they either make use of retrospective recall or participant interviews to collect their accounts of what people are thinking about. The few studies using thought diaries (Unsworth & McMillan, 2017; Unsworth et al., 2012) do not relate the more in-depth thought reports to well-being or to the context in which they occur. As such, we do not know how stable the relationships between the social and temporal dimensions of thoughts and well-being are within individuals.

Thought prompts eliciting more precise descriptions of thoughts may be able to answer this question, however, experience sampling studies are likely to encounter similar trade-offs between conciseness and precision in relation to thoughts to those described in the previous section for well-being. The resulting study design is likely to impact both the kind of responses that the participants provide (see also, Robison et al., 2019) and the inferences that researchers can make about the relationship between thoughts and well-being. The granularity and robustness of these inferences will in turn determine whether they can reliably be used to design better personalised well-being enhancing interventions.

Overarching limitations and future research

While we discussed the limitations associated with each chapter in the discussion part of that chapter, there are a couple of overarching limitations to this thesis that were not mentioned in each individual study. We briefly address these here, before detailing some suggestions for future research.

Participant attrition

In chapter 2 (p. 49), we briefly discussed how we dealt with attrition in our sample. Finding little observable differences between participants who dropped out along the way and those who remained in the study until the end, we elected to treat missing datapoints as *missing at random*. However, it is plausible that data were missing non-randomly in some cases, particularly when it came to which questionnaires participants did not answer. Indeed, if certain thoughts, activities, company or even well-being states made it more or less likely for participants to check their phones or to open the app's notifications, this might have led to some non-randomness in which questionnaires were answered and which were not. While there is no definite way of telling how this would affect our estimates and their significance in chapters 3 to 5, we discuss potential outcomes and their consequences below:

(1) In the scenario where people systematically answered less EMA reports when they were fully focused on the present activity, our study would have overestimated the proportion of TUT that people actually experienced. If this were the case, it is also most likely a limitation of previous studies that looked at the effects of TUT on well-being using EMA-type studies. However, our rate of TUT reports seems consistent with previous experimental studies too, suggesting that it may not be an issue.

(2) In the scenario where people systematically answered less EMA reports when they were experiencing certain levels of well-being, our average level of momentary well-

being may have been biased (downwards if people answered less EMA prompts when they experienced high levels of well-being, and vice versa). This is not a problem in terms of establishing the within-person effects of thoughts on well-being, as long as our data include at least some reports at every level of well-being, which they do. Similarly, if people answered systematically less EMA reports when they were experiencing the most extreme levels of well-being (i.e., both highest and lowest), this would have reduced the variance in well-being reports and potentially have impacted the size of the coefficients. However, this is more likely to lead to an underestimation of the effect of thoughts on well-being, rather than an overestimation, in which case we can still rely on the significance of the coefficients that we discussed across chapters 3 to 5.

(3) The most problematic scenario is the one where people answered systematically less EMA reports when they were engaged in certain activities and when they were with a certain kind of company. Following our findings in chapter 5, since we can expect the relationship between thoughts and well-being to vary depending on the context in which they are reported, then non-random missing observation related to specific activities and/or company might have caused us to misreport the general relationship between thoughts and well-being. While there is no way to definitively determine the extent of non-random missing data that resulted from this, the analysis in chapter 5 somewhat addresses this issue by exploring how the relationship between thoughts and well-being differs depending on the activity and the company.

All in all, participant attrition and the non-randomness of missing data are difficult limitations to address, as the causes of these phenomena are most often unobservable in studies that follow people as they go about their daily lives. While niche, qualitative explorations to address this issue may exist (e.g., Heitmayer & Lahlou, 2021), it remains an accepted limitation of ecologically valid experience sampling studies in general.

Other overarching limitations

The first overarching limitation is that across chapters 3 to 6, we were unable to unearth the psychological mechanisms behind our findings. We have provided a clearer picture of what the relationship between thoughts and well-being looks like, but we can only speculate as to *why* this relationship is as it is. In the introduction and in this general discussion, we have discussed a number of potential mechanisms that might explain our

findings and those reported in the previous literature, but our evidence is largely correlational and focused on the outcome of internal processes, rather than on the processes themselves. While this is a common limitation of most psychological research, modern tools combining experimental data with technology such as neuroimaging might allow us to get closer to uncovering the internal mechanisms that drive the relationship between thoughts and well-being.

The second overarching limitation comes from the fact that chapters 3 to 5 all use the same dataset. This means that we were not able to replicate the findings we present in this thesis in any different settings, whether using more experience sampling or experimental designs. The incredible richness of this dataset allowed us to explore questions that had not been asked in the previous literature to date, but it came at an important practical cost. Indeed, between the design of the app, the set-up of the data collection and the payment of participants, the financial costs of the study were simply too large to consider a point-by-point replication.

As a result, study 3, presented in chapter 6, which was the follow-up of the larger study that was used in chapter 3 to 5, did not include EMA questionnaires, thus limiting our ability to use any of its results to discuss the relationship between thoughts and well-being, as we would have been relying on retrospective accounts of thoughts and well-being, rather than momentary ones.

The third overarching limitation is that the EMA questionnaires that were used to collect the data used in chapters 3 to 5 were designed without randomising the order of the questions that participants answered. As a result, the decision to ask people about context first, then thoughts, and to conclude with well-being, may have led participants to systematically anchor on previous answers in later questions. For example, since people reported the valence of their thoughts shortly before reporting their well-being, their assessment of whether their thoughts were positive, neutral or negative could have influenced their subsequent reports of how they felt. Alternatively, always asking people about context first might have made it more difficult for people to subsequently remember the exact content of their thoughts at the time of notification. Replications of the papers presented in this thesis should consider introducing some amount of randomisation in the order in which they present their questions to account for this.

The final overarching limitation is that our entire analysis of the relationship between thoughts and well-being was exploratory. As the study was originally designed to answer different well-being related questions, such as whether reporting well-being can improve well-being (chapter 6), whether there is a difference between DRM and EMA in reporting well-being (Henwood et al., 2022), or whether passively collected smartphone data can predict self-reported well-being (Buda et al., 2021), the pre-registration did not include any hypotheses regarding the relationship between thoughts and well-being.

While this was not too problematic in chapter 3, as there was plenty of literature to compare our findings to, the exploratory nature of our analyses in chapters 4 and 5 will certainly require pre-registered replications to demonstrate their reliability and generalisability. In this thesis, we favoured breadth over depth, hoping to provide a foundation for what we believe to be several important developments in the literature around the relationship between thoughts and well-being.

Future research

Several avenues for future research have already been mentioned in the discussion sections of each chapter. These include replications of the findings around personality and context, but mostly, extensions on the studies conducted in this thesis. The most obvious of these would involve the collection of additional measures and variables alongside the ones that were collected as part of this work.

At the EMA stage, this would involve asking people about (1) different well-being measures, particularly experiences of negative affect, which were not collected at the EMA level; (2) different components of thoughts, such as intentionality or vividness, depending on which of these components are expected to be related to well-being; and (3) different elements of context, such as weather, to continue exploring how external factors influence our thoughts and well-being.

During the set-up of the study, it would involve asking people to report more or different individual-specific characteristics. Among others, cultural background, cognitive capacity, religious and spiritual beliefs (Kapuscinski & Masters, 2010), emotional self-awareness (Lane et al., 1990), and trait mindfulness (Cardaciotto et al., 2008; Lau et al., 2006) might constitute interesting additions to explore whether we can more reliably capture the moderation effect of individual-specific characteristics on the relationship between thoughts and well-being.

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These additions to similar datasets as the one used in chapters 3 to 5 will further contribute to the exploration of the links outlined in our discussion of the overarching thoughts model of well-being. In doing so, they may also contribute to the practical challenges we outlined for the design of thought-related well-being interventions. That being said, further research may also want to explore some of the questions that we raised in this thesis using different methodological approaches.

In particular, the moderating effect of individual-specific characteristics on the relationship between thoughts and well-being may be better explored using experiments before going back to ecologically valid settings. This might allow researchers to form an idea of which traits are most predictive of the relationship between thoughts and well-being in a controlled environment, and to design later experience sampling studies accordingly. The experimental environment might also allow researchers to compare scale-based individual-specific measures like personality to performance-based ones like working memory capacity, as the latter would be easier to assess without the noise of uncontrolled day-to-day settings.

Experimental environments may also be more suitable to study the mechanisms that drive the relationship between mind wandering and well-being. Specifically, the *experience dampener hypothesis* and the *attentional failure hypothesis* may be better tested in controlled environments, using high and low attention-demanding tasks, as well as tasks that are perceived more or less negatively by participants. One particularly interesting avenue would be to find a task or an activity that is highly polarising, in the sense that some participants will perceive it as negative, while others will view it as positive. Using a neutral activity as a baseline, we could then look at (1) whether participants who rate the activity as negative report relatively more mind wandering than participants who rate it positively, and (2) whether mind wandering is associated to higher well-being when among participants who report the activity as negative, and vice versa. Such experiments should of course incorporate measures of both happiness and worthwhileness.

In addition, researchers looking into how the relationship between thoughts and well-being varies depending on context might want to collect experience sampling data, but only in specific contexts. This would allow them to focus on certain activities that were not analysed in chapter 5, like exercise, reading or meditation. In addition, the present analysis of how the relationship between thoughts and well-being varies by context made use of sub-sample analysis, but another recent study has explored this question using interaction terms in

multi-level models (Nyklíček et al., 2021), highlighting other statistical methodologies to address this question too. Large-scale studies could consider exploring context as the interaction between activities and company or incorporate other elements of context (as discussed previously, p. 118) into the sub-sample analysis. Taking it one step further, such studies could even look into the moderating effect of individual-specific characteristics and context simultaneously, although this might require yet another statistical approach (e.g., dynamic structural equation modelling; Asparouhov et al., 2018).

When it comes to the implementation of thought-related interventions in mobile apps, researchers could explore the impact of incorporating basic exercises to address the occurrence of negative thoughts, such as cognitive defusion or cognitive restructuring (Deacon et al., 2011; Larsson et al., 2016; Masuda et al., 2005), on both experienced (as in chapters 3 to 5) and evaluated well-being (chapter 6). Such exercises might take the form of asking people to challenge the validity of their negative thoughts by making them list evidence for and against these thoughts, then reformulate them to be more realistic (see Arch & Carske, 2008). As stand-alone interventions, such exercises could be incorporated within EMA questionnaires like the ones used in studies 1 and 2 of chapter 6, or as part of a daily DRM-type check-up.

Finally, RCTs of the same kind as those reported in chapter 6 could be used compare thought-related interventions to both simpler and more complex interventions, ranging from the mere reporting exercise that was discussed in chapter 6 to mobile apps that provide a full range of CBT-related well-being interventions. To understand where thought-related interventions fit in the space of self-help tools and how they compare to other well-being enhancing interventions is the next necessary step to bridge the gap between the academic exploration of these internal processes and the practical implementation of the resulting knowledge.

Conclusion

In this thesis, we contribute to the growing understanding of the internal determinants of well-being, and to how this understanding may be applied in practice to improve people's well-being as they go about their day-to-day lives. As such, we hope that this thesis will serve as a foundation for future work that attempts of incorporate the relationship between thoughts and well-being into well-being enhancing interventions.

Self-help apps have made well-being and mental health improvement just a few clicks or taps away for people all around the world. In the coming years, their convenience and ubiquity may even come to substitute clinical interventions for some people. While this could be encouraging, it presently constitutes a formidable challenge: that of making sure that these digital tools can actually deliver on what they promise. That is, in large part, the role of researchers like us. We seek to better understand how people feel and what internal and external processes drive these feelings, in order to provide evidence-based frameworks for app developers and intervention designers. But understanding how people think and feel is only part of the solution.

While we get to observe and quantify relationships between the different things that our participants tell us, the real mechanisms behind these relationships often remain hidden from us. We may understand that past-related thoughts cause lower happiness, or that mind wandering is associated with higher happiness when we are with our partner, but this does not necessarily mean that asking people to deliberately avoid past-related thoughts, or to deliberately let their minds wander when they are with their partner, will in fact improve their happiness. The implementation of these insights into self-help technologies must be tested before their practical impact can be determined.

As such, the findings in this thesis are but a few steps in the complex journey towards the better understanding of how people feel and towards the creation of tools that may one day generate large-scale improvements in individual well-being across society. We believe that such tools might benefit from incorporating the broader literature on the relationship between thoughts and well-being into their design, and from favouring simple interventions (like repeatedly filling in EMA questionnaires) that may trigger adaptive internal mechanisms over excessively complex ones.

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Appendix

A1. Questionnaires

Onboarding questionnaire (all papers)

A. ONS-4

1. Overall, how satisfied are you with your life nowadays?
2. Overall, to what extent do you feel the things you do in your life are worthwhile?
3. Overall, how happy did you feel yesterday?
4. Overall, how anxious did you feel yesterday?
5. Overall, how happy do you feel in general?
6. Overall, how anxious do you feel in general?

B. Happy/worthwhile balance

1. What is your balance between happy and worthwhile experiences nowadays? Move the slider below until it reaches a point that best represents your balance, then click the next button down there on the right.

      0. Happy

      1. Worthwhile

2. And what is your ideal balance between happy and worthwhile experiences nowadays? Move the slider below until it reaches a point that best represents your ideal balance, then click the next button down there on the right.

      0. Happy

      1. Worthwhile

C. Basic demographic information (Students and staff)

- Age
- Gender
- Employment status
- Part- or full-time work
- Monthly income (brackets)
- Social media usage (Facebook, Instagram)

D. Individual specific characteristic questionnaires

Title: "Questionnaire 5 of 11" (Self-esteem)

      1. On the whole, I am satisfied with myself. (type=radio)

      2. At times, I think I am no good at all. (type=radio)

      3. I feel that I have a number of good qualities. (type=radio)

4. I am able to do things as well as most other people. (type=radio)

5. I feel I do not have much to be proud of. (type=radio)

6. I certainly feel useless at times. (type=radio)

7. I feel that I'm a person of worth, at least on an equal plane with others. (type=radio)

8. I wish I could have more respect for myself. (type=radio)

9. All in all, I am inclined to feel that I am a failure. (type=radio)

10. I take a positive attitude toward myself. (type=radio)

Scale:

0. Strongly disagree

1. Disagree

2. Agree

3. Strongly agree

Title: "Questionnaire 6 of 11" (Delayed Gratification)

In each of the following questions you must choose between two monetary payment options. Please note that there is a chance that one of your answers will be selected to give you a real payment based on your preferred choice in that question. So please answer carefully.

1. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

Option A: £100 today

Option B: £105 in 6 months

2. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

Option A: £100 today

Option B: £110 in 6 months

3. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

Option A: £100 today

Option B: £120 in 6 months

4. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

Option A: £100 today

Option B: £130 in 6 months

5. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 today

        Option B: £150 in 6 months

6. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 today

        Option B: £200 in 6 months

7. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £105 in 7 months

8. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £110 in 7 months

9. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £120 in 7 months

10. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £130 in 7 months

11. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £150 in 7 months

12. You have to choose between the two monetary payments below, option A and option B. Which option do you prefer? Please tick your preferred option. (type=radio)

        Option A: £100 in 1 month

        Option B: £200 in 7 months

Title: "Questionnaire 7 of 11" (Sense of control)

    1. I can do just about anything I really set my mind to. (type=radio)

2. When I really want to do something I usually find a way to succeed. (type=radio)

3. Whether or not I am able to get what I want is in my own hands. (type=radio)

4. What happens to me in the future mostly depends on me. (type=radio)

5. Other people determine what I can and cannot do. (type=radio)

6. There is little I can do to change the important things in my life. (type=radio)

7. I often feel helpless in dealing with the problems of life. (type=radio)

8. What happens in my life is often beyond my control. (type=radio)

9. There are many things that interfere with what I want to do. (type=radio)

10. I have little control over the things that happen to me. (type=radio)

11. There really is no way I can solve all the problems I have. (type=radio)

12. I sometimes feel I am being pushed around in my life. (type=radio)

Scale:

0. Strongly disagree

1. Somewhat disagree

2. Disagree a little

3. Don't know

4. Agree a little

5. Somewhat agree

6. Strongly agree

Title: "Questionnaire 9 of 11" (Big 5)

1. I am the life of the party. (type=radio)

2. I feel little concern for others. (type=radio)

3. I am always prepared. (type=radio)

4. I get stressed out easily. (type=radio)

5. I have a rich vocabulary. (type=radio)

6. I don't talk a lot. (type=radio)

7. I am interested in people. (type=radio)

8. I leave my belongings around. (type=radio)

9. I am relaxed most of the time. (type=radio)

10. I have difficulty understanding abstract ideas. (type=radio)

11. I feel comfortable around people. (type=radio)

12. I insult people. (type=radio)

13. I pay attention to details. (type=radio)

14. I worry about things. (type=radio)

15. I have a vivid imagination. (type=radio)

16. I keep in the background. (type=radio)

17. I sympathize with others' feelings. (type=radio)

18. I make a mess of things. (type=radio)

19. I seldom feel blue. (type=radio)

20. I am not interested in abstract ideas. (type=radio)

21. I start conversations. (type=radio)

22. I am not interested in other people's problems. (type=radio)

23. I get chores done right away. (type=radio)

24. I am easily disturbed. (type=radio)

25. I have excellent ideas. (type=radio)

26. I have little to say. (type=radio)

27. I have a soft heart. (type=radio)

28. I often forget to put things back in their proper place. (type=radio)

29. I get upset easily. (type=radio)

30. I do not have a good imagination. (type=radio)

31. I talk to a lot of different people at parties. (type=radio)

32. I am not really interested in others. (type=radio)

33. I like order. (type=radio)

34. I change my mood a lot. (type=radio)

35. I am quick to understand things. (type=radio)

36. I don't like to draw attention to myself. (type=radio)

37. I take time out for others. (type=radio)

38. I shirk my duties. (type=radio)

39. I have frequent mood swings. (type=radio)

40. I use difficult words. (type=radio)

41. I don't mind being the center of attention. (type=radio)

42. I feel others' emotions. (type=radio)

43. I follow a schedule. (type=radio)

44. I get irritated easily. (type=radio)

45. I spend time reflecting on things. (type=radio)

46. I am quiet around strangers. (type=radio)

47. I make people feel at ease. (type=radio)

48. I am exacting in my work. (type=radio)

49. I often feel blue. (type=radio)

50. I am full of ideas. (type=radio)

Scale:

    0. Very Inaccurate

    1. Moderately Inaccurate

    2. Neither Accurate Nor Inaccurate

    3. Moderately Accurate

    4. Very Accurate

Title: "Questionnaire 10 of 11" (Uncertainty)

1. Unforeseen events upset me greatly. (type=radio)

2. It frustrates me not having all the information I need. (type=radio)

3. One should always look ahead so as to avoid surprises. (type=radio)

4. A small, unforeseen event can spoil everything, even with the best of planning. (type=radio)

5. I always want to know what the future has in store for me. (type=radio)

6. I can't stand being taken by surprise. (type=radio)

7. I should be able to organize everything in advance. (type=radio)

8. Uncertainty keeps me from living a full life. (type=radio)

9. When it's time to act, uncertainty paralyses me. (type=radio)

10. When I am uncertain I can't function very well. (type=radio)

11. The smallest doubt can stop me from acting. (type=radio)

12. I must get away from all uncertain situations. (type=radio)

Scale:

    0. Strongly Disagree

    1. Moderately Disagree

    2. Neither Disagree nor Agree

    3. Moderately Agree

    4. Strongly Agree

E. Temporal perception

How long do you think you've spent on this app so far?

Please wait (don't close the app)

How long do you think you've just been waiting?

Exit questionnaire (all papers)

Title: **"Exit questionnaire"**

1. Overall, how satisfied are you with your life nowadays?

2. Overall, to what extent do you feel the things you do in your life are worthwhile?

3. Overall, how happy did you feel yesterday?

4. Overall, how anxious did you feel yesterday?

5. Overall, how happy do you feel in general?

6. Overall, how anxious do you feel in general?

7. Do you feel that you are more aware of what drives your mood now than you were at the beginning of the study? (Likert scale: 5-much more, 4-a little more, 3-no change, 2-a little less, 1-much less)

8. Have you changed your perception on any of the activities, thoughts or people listed during this study? (Likert scale: 5-much more, 4-a little more, 3-no change, 2-a little less, 1-much less)

EMA questionnaire (papers 1-3; paper 4, study 1 and 2)

1) What were you doing just now?

- Working
- Commuting
- Eating
- Shopping
- At the supermarket
- Emails
- Listening to Music
- Taking a nap
- Waiting
- Reading
- Exercise (gym, jogging, swimming, add more, etc.)
- Studying
- Taking a shower
- Conversation
- Watching TV

- Using social media
- Browsing internet
- Playing video games
- ADD [Open text box]

1a) Custom Student Activity List

- Commuting
- Eating
- Exercising
- Socialising
- Watching TV
- Social Media
- Lecture
- Seminar
- Exam
- Studying
- Meeting
- Careers centre
- IT support
- Counselling
- Human resources
- Society/club
- ADD [Open text box]

1b) Custom Staff Activity List

- Commuting
- Eating
- Exercising
- Socialising
- Watching TV
- Teaching
- Presentation
- Admin
- Meeting

- Emails
- IT support
- Counselling
- Human resources
- Finance
- Overtime
- Cleaning
- ADD NEW [Open text box]

2) How long have you been doing this?

Drop down in 10-minute increments, from 10 minutes to 4hr 10min.

3) I was with:

- Colleagues
- Friend(s)
- Kids
- Partner
- People that I didn't know before
- Alone
- Family
- ADD [Open text box]

4) I was thinking about: [TREATMENT GROUP ONLY]

- Current activity
- Kids
- Health
- Partner
- Friends
- Events from last day(s)
- Events from my past
- Food
- About tomorrow
- About my future
- ADD [Open text box]

4a) [AFTER SELECTING A THOUGHT] **This thought was: [TREATMENT GROUP ONLY]**

- Positive

- Neutral

- Negative

5) Where are you?

- Home

- Work

- University

- Library

- Sports facility

- Public transport

- Restaurant

- Bar/club

- Cinema

- Supermarket

- Street/outdoors

- At my parents' house

- At my friends house

- Holidays, away from my home city

- ADD [Open text box]

6) How happy did you feel? [TREATMENT GROUP ONLY]

SCALE: Not at all 0 1 2 3 4 5 6 7 8 9 10 Completely

7) How worthwhile did this feel? [TREATMENT GROUP ONLY]

SCALE: Not at all 0 1 2 3 4 5 6 7 8 9 10 Completely

8) How do you feel at the moment? (Choose the one that describes your current state best)

[TREATMENT GROUP ONLY]

Stressed	Tense	Excited
Sad / Upset	Neutral	Serene / Happy
Depressed	Fatigued	Calm / Relaxed
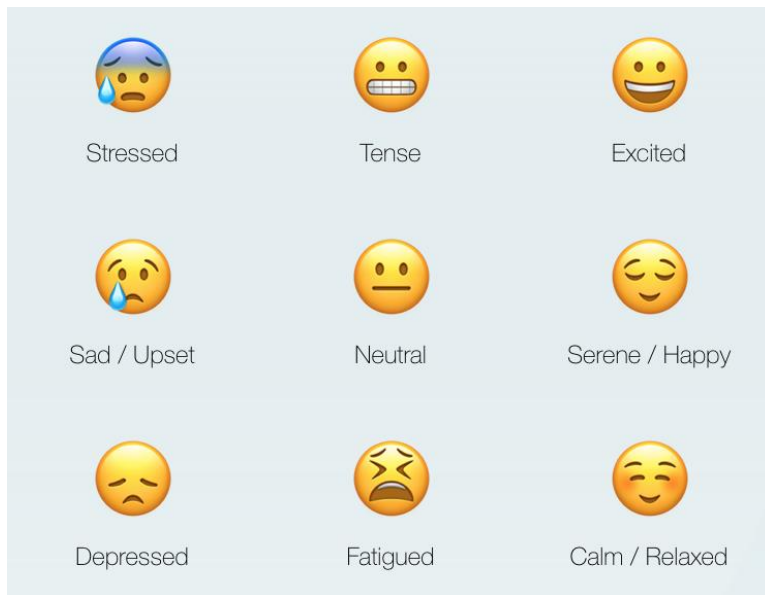
+ Additional info from the final EMA of the day [TREATMENT GROUP ONLY]

1. Overall, how satisfied were you with your life **today**? **[TREATMENT GROUP ONLY]**

2. Overall, to what extent do you feel the things you did **today** were worthwhile? **[TREATMENT GROUP ONLY]**

3. Overall, how happy did you feel **today**? **[TREATMENT GROUP ONLY]**

4. Overall, how anxious did you feel **today**? **[TREATMENT GROUP ONLY]**

5. How many hours did you sleep last night?

SCALE: <6, 6 - 7, 7 - 8, 8 - 9, 9 -10, 10 - 11, >11

6. How much time did you spend doing sport today?

SCALE: 0 - 4 hours

7. How productive were you today?

SCALE: Completely unproductive 0 1 2 3 4 5 6 7 8 9 10 Very productive

8. How much quality time did you have with friends today?

SCALE: No quality time at all 0 1 2 3 4 5 6 7 8 9 10 Lots of quality time

DRM questionnaires (paper 4)

Instructions: Think of your day yesterday as a continuous series of scenes or episodes in a film. Give each episode a brief name that will help you remember it (for example, 'commuting to work', or 'at lunch with B'...). Write down the approximate times at which each episode began and ended.

Start time - End Time

__:__   until __:__

I was doing:

- Working
- Commuting
- Eating
- Shopping
- At the supermarket
- Emails
- Listening to Music
- Taking a nap
- Waiting
- Reading
- Exercise (gym, jogging, swimming, add more, etc.)
- Studying
- Taking a shower
- Conversation
- Watching TV
- Using social media
- Browsing internet
- Playing video games
- ADD [Open text box]

1a) Custom Student Activity List

- Commuting
- Eating
- Exercising
- Socialising
- Watching TV
- Social Media
- Lecture
- Seminar
- Exam
- Studying

- Meeting
- Careers centre
- IT support
- Counselling
- Human resources
- Society/club
- ADD [Open text box]

1b) Custom Staff Activity List

- Commuting
- Eating
- Exercising
- Socialising
- Watching TV
- Teaching
- Presentation
- Admin
- Meeting
- Emails
- IT support
- Counselling
- Human resources
- Finance
- Overtime
- Cleaning
- ADD NEW [Open text box]

2) I was with:

- Colleagues
- Friend(s)
- Kids
- Partner
- People that I didn't know before
- Alone

- Family
- ADD [Open text box]

3) I was thinking about: [TREATMENT GROUP ONLY]

- Current activity
- Kids
- Health
- Partner
- Friends
- Events from last day(s)
- Events from my past
- Food
- About tomorrow
- About my future
- ADD [Open text box]

3a) [AFTER SELECTING A THOUGHT] **This thought was: [TREATMENT GROUP ONLY]**

- Positive
- Neutral
- Negative

4) Where are you?

- Home
- Work
- University
- Library
- Sports facility
- Public transport
- Restaurant
- Bar/club
- Cinema
- Supermarket
- Street/outdoors
- At my parents' house

- At my friends house

- Holidays, away from my home city

- ADD [Open text box]

5) How happy did you feel? [TREATMENT GROUP ONLY]

SCALE: Not at all 0 1 2 3 4 5 6 7 8 9 10 Completely

6) How worthwhile did this feel? [TREATMENT GROUP ONLY]

SCALE: Not at all 0 1 2 3 4 5 6 7 8 9 10 Completely

Onboarding + exit (paper 4, study 3 only)

A. Demographic information [ONBOARDING ONLY]

- Age

- Gender

- Employment status

- Part- or full-time work

- Monthly income (brackets)

- Student status

- Year of study

- Study level

- Region of origin

- Place of residence during Covid-19

- Current place of residence

- Funding status

B. ONS 4 extended

1. Overall, how satisfied are you with your life?

2. Overall, to what extent do you feel the things you do in your life are worthwhile?

3. Overall, how happy did you feel yesterday?

4. Overall, how anxious did you feel yesterday?

5. Overall, how happy do you feel in general?

6. Overall, how anxious do you feel in general?

7. How happy do you feel today?

Note that some questions that you answered refer to different kinds of being happy.

Imagine that someone could ask you only one of the following two questions for the rest of your life to understand your happiness. Which one would you consider as the most important question:

[ ] Overall, how satisfied are you with your life?

[ ] How happy do you feel today? (repeatedly asked)

C. PSS-10

Introduction: The questions in this scale ask about your feelings and thoughts during the last week. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly.

Questions:

1. In the last week, how often have you been upset because of something that happened unexpectedly?
2. In the last week, how often have you felt that you were unable to control the important things in your life?
3. In the last week, how often have you felt nervous and "stressed"?
4. In the last week, how often have you felt confident about your ability to handle your personal problems?
5. In the last week, how often have you felt that things were going your way?
6. In the last week, how often have you found that you could not cope with all the things that you had to do?
7. In the last week, how often have you been able to control irritations in your life?
8. In the last week, how often have you felt that you were on top of things?
9. In the last week, how often have you been angered because of things that were outside of your control?
10. In the last week, how often have you felt difficulties were piling up so high that you could not overcome them?

SCALE: never (0) - very often (4)

D. PHQ-8

Questions: Over the last two weeks, how often have you been bothered by any of the following problems?

1. Little interest or pleasure in doing things?
2. Feeling down, depressed, or hopeless?
3. Trouble falling or staying asleep, or sleeping too much?

4. Feeling tired or having little energy?

5. Poor appetite or overeating?

6. Feeling bad about yourself - or that you are a failure or have let yourself or your family down?

7. Trouble concentrating on things, such as reading the newspaper or watching television?

8. Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual?

SCALE: Not at all (0), Several days (1), More than half the days (3), Nearly every day (4)

E. GAD-7

Questions: Over the last week, how often have you been bothered by the following problems?

1. Feeling nervous, anxious, or on edge

2. Not being able to stop or control worrying

3. Worrying too much about different things

4. Trouble relaxing

5. Being so restless that it's hard to sit still

6. Becoming easily annoyed or irritable

7. Feeling afraid as if something awful might happen

SCALE: Not at all sure (0), Several days (1), Over half the days (2), Nearly every day (3)

F. WHO-5

Introduction: Please indicate for each of the five statements which is closest to how you have been feeling over the last week. Notice that higher numbers mean better well-being.

Questions:

1. I have felt cheerful and in good spirits

2. I have felt calm and relaxed

3. I have felt active and vigorous

4. I woke up feeling fresh and rested

5. my daily life has been filled with things that interest me

SCALE: All of the time (5), Most of the time (4), More than half of the time (3), Less than half of the time (2), Some of the time (1), At no time (0)

G. CD-RISC 10

Introduction: Please indicate how much you agree with the following statements as they apply to you over the last week. If a particular situation has not occurred recently, answer according to how you think you would have felt.

Questions:

1. I am able to adapt when changes occur.
2. I can deal with whatever comes my way.
3. I try to see the humorous side of things when I am faced with problems.
4. Having to cope with stress can make me stronger.
5. I tend to bounce back after illness, injury, or other hardships.
6. I believe I can achieve my goals, even if there are obstacles.
7. Under pressure, I stay focused and think clearly.
8. I am not easily discouraged by failure.
9. I think of myself as a strong person when dealing with life's challenges and difficulties.
10. I am able to handle unpleasant or painful feelings like sadness, fear, and anger.

SCALE: Not true at all (0), Rarely true (1), Sometimes true (2), Often true (3), True nearly all the time (4)

Additional weekly questions (paper 1-3; paper 4, studies 1 and 2)

Note that the following questions refer to the past week!

1. Overall, how satisfied were you with your life **this week**?
2. Overall, to what extent do you feel the things you did **this week** were worthwhile?
3. Overall, how happy did you feel **this week**?
4. Overall, how anxious did you feel **this week**?
5. Select the days on which you expect to have events that you are looking forward to (during the following week). (type=checkbox)
   - Monday
   - Tuesday
   - Wednesday
   - Thursday
   - Friday
   - Saturday
   - Sunday

- None

6. Select the days on which you expect to have events that you are NOT looking forward to (during the following week)..

- Monday

- Tuesday

- Wednesday

- Thursday

- Friday

- Saturday

- Sunday

- None

A2. Supplementary materials: chapter 3

Note on coding of interaction terms

Coding of interactions terms was done manually, through the creation of an additional variable for each interaction that was tested. This was done to make sure that every individual thought was captured appropriately in our regression models. For example, if an entry includes a TCA report of neutral valence and a TUT report of positive valence, the variables for TCA, TUT, positive valence and neutral valence are all assigned a value of 1. For this reason, separate variables are created to capture the interaction between valence and type of thought, such that, in this example, the variable for positive TUT and neutral TCA are both assigned a value of 1, while the variables for neutral TUT and positive TCA retain a value of 0. This is done for interactions between type and valence, and for the interaction between social and temporal content of thoughts.

Simplified models (comparison to Killingsworth & Gilbert, 2010)

	DV: Exp. happiness	*DV:* Exp. worthwhileness
Type (base: TCA)		
TUT	-0.133** (0.043)	-0.214*** (0.055)
TUT & TCA	0.268*** (0.052)	0.359*** (0.064)
Valence		
Positive	0.947*** (0.065)	0.677*** (0.070)
Neutral	-0.240*** (0.054)	-0.333*** (0.062)
Negative	-1.395*** (0.066)	-1.126*** (0.075)
Additional TUT	0.074* (0.034)	0.026 (0.040)
N. of observations (entries)	15901	15948
N. of entities (individuals)	524	522

F-test	234.87	123.03
R²	0.2575	0.1242

*Table A2.1: Simplified models of the relationship between experienced well-being and type and valence of thoughts. *: p<0.05, **: p<0.01, ***: p<0.001*

Full figures of effect sizes of main regressions
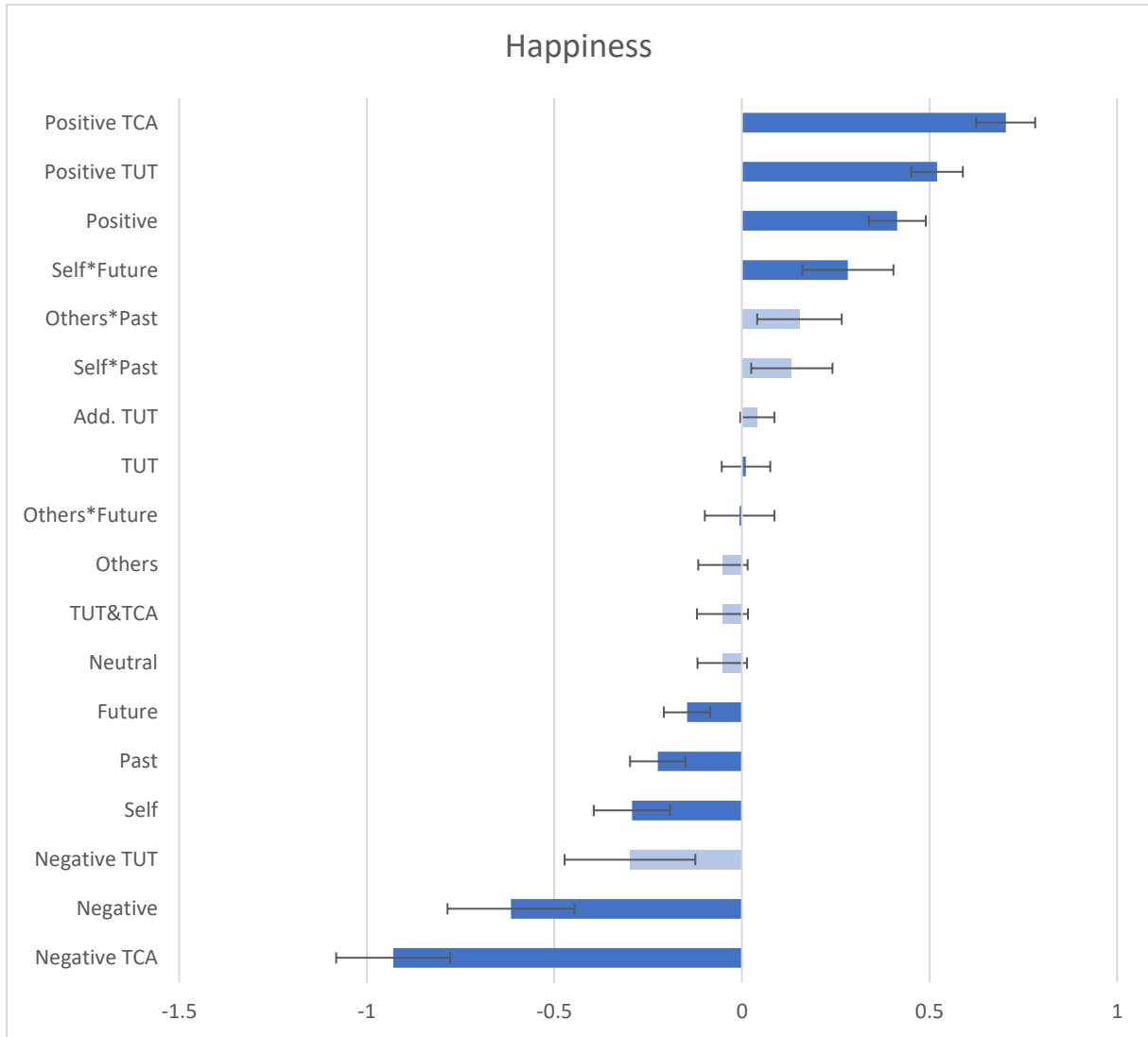
Figure A2.1: Graphical representation of sign, magnitude and significance of the effect of all components of thought, including interactions on experienced happiness, including clustered standard errors.
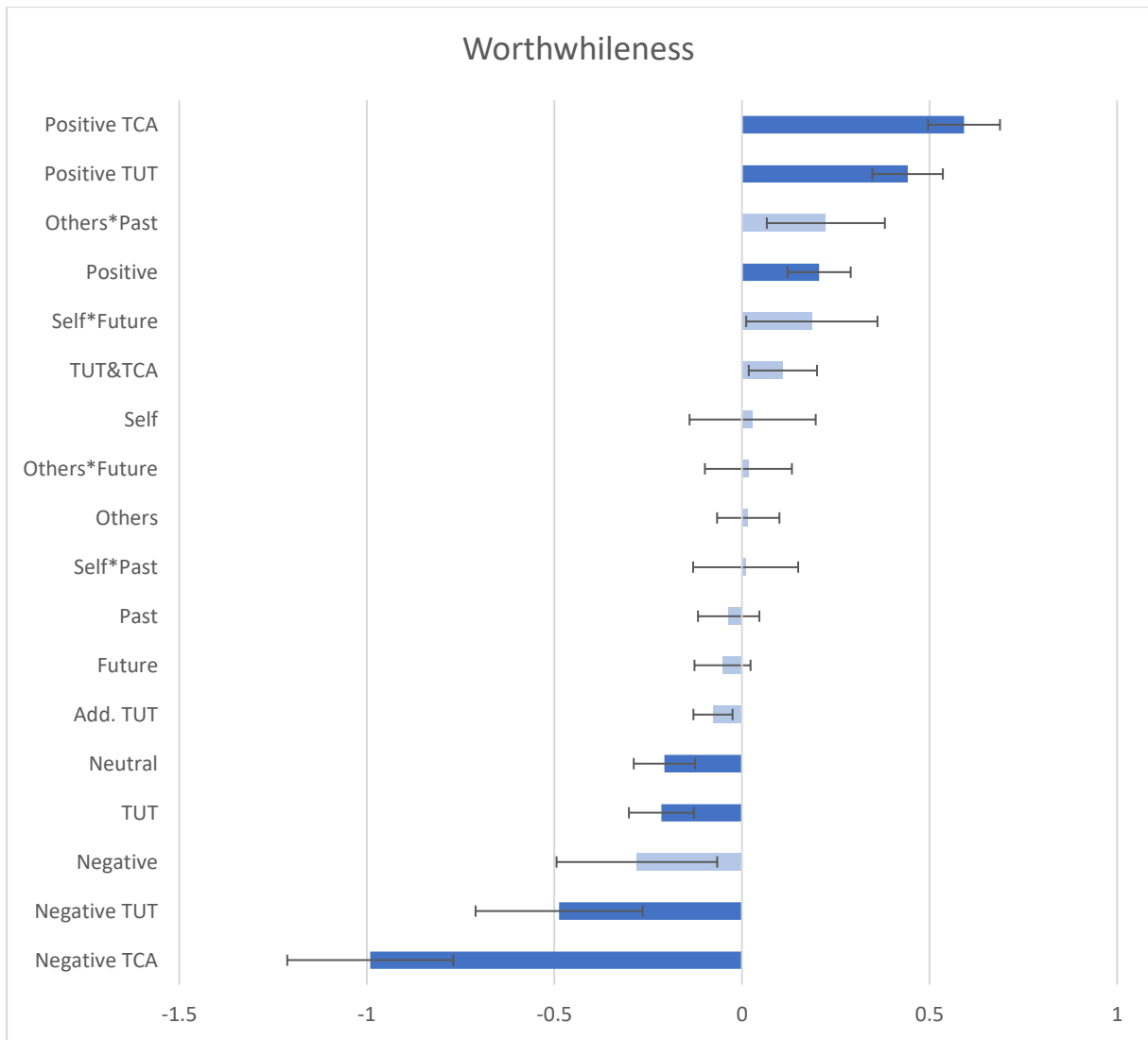
Figure A2.2: Graphical representation of sign, magnitude and significance of the effect of all components of thought, including interactions on experienced worthwhileness, including clustered standard errors.

Results for t+1 regressions

In addition to our causality models, we run an alternative lagged model to check whether estimates at t+1 predicted experienced happiness at t (similar to Killingsworth & Gilbert, 2010), and find no significant effects for any of the variables that significantly caused well-being in our models including t-1 lags, which is what we would expect if thoughts indeed caused experienced happiness rather than the other way around. Interestingly, we do find that positive thoughts at t+1 significantly predict experienced happiness at t, suggesting that experienced happiness may cause people to report more positive thoughts in the future. As such, while thoughts appear to cause experienced happiness more than the other way around, we find some evidence of a dynamic relationship between valence of thoughts and experienced happiness. We find no significant coefficients in the same model using worthwhileness as a dependent variable. Coefficients, significance and standard errors of t+1 fixed effects models for happiness and worthwhileness are reported in the tables below.

DV: Experienced happiness	(1)	(2)
Type (base: TCA)		
TUT	-0.073 (0.052)	-0.077 (0.073)
TUT & TCA	0.261*** (0.052)	0.196** (0.066)
Valence		
Positive	0.948*** (0.064)	0.853*** (0.069)
Neutral	-0.232*** (0.054)	-0.157* (0.062)
Negative	-1.379*** (0.067)	-1.128*** (0.073)
Add. TUT	0.109** (0.041)	0.102* (0.046)
Social content (base: Not specified)		
Others	-0.010 (0.060)	-0.033 (0.068)
Self	-0.054 (0.051)	-0.036 (0.078)
Temporal content (base: Not specified)		
Past	-0.119 (0.064)	-0.094 (0.082)
Future	-0.072 (0.048)	0.006 (0.069)
Type (t+1)		
TUT (t+1)		0.017 (0.065)
TUT & TCA (t+1)		-0.057 (0.067)
Valence (t+1)		
Positive (t+1)		0.165** (0.060)
Neutral (t+1)		0.064 (0.057)
Negative (t+1)		0.043 (0.061)
Add. TUT (t+1)		-0.086 (0.049)
Social content (t+1)		
Others (t+1)		-0.107 (0.067)
Self (t+1)		0.049 (0.072)
Temporal content (t+1)		
Past (t+1)		0.050 (0.081)

		0.077 (0.067)
N. of observations (entries)	15901	10608
N. of entities	524	4232
F-test	139.98	48.342
R²	0.2582	0.2118

Table A2.1: Regression coefficients, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models predicting experienced happiness including time lags for (2) t+1

DV: Exp. worthwhileness	(1)	(2)
Type (base: TCA)		
TUT	-0.278*** (0.072)	-0.393*** (0.093)
TUT & TCA	0.349*** (0.064)	0.443*** (0.094)
Valence		
Positive	0.675*** (0.070)	0.609*** (0.090)
Neutral	-0.336*** (0.062)	-0.229** (0.085)
Negative	-1.140*** (0.074)	-0.981*** (0.097)
Add. TUT	-0.026 (0.048)	-0.020 (0.069)
Social content (base: Not specified)		
Others	0.091 (0.071)	0.183* (0.089)
Self	0.179* (0.079)	0.114 (0.106)
Temporal content (base: Not specified)		
Past	0.042 (0.076)	-0.035 (0.104)
Future	-0.004 (0.071)	-0.077 (0.093)
Type (t+1)		
TUT (t+1)		0.055 (0.082)
TUT & TCA (t+1)		-0.024 (0.085)
Valence (t+1)		
Positive (t+1)		0.012 (0.082)
Neutral (t+1)		0.018 (0.079)
Negative (t+1)		-0.008 (0.086)
Add. TUT (t+1)		-0.032 (0.063)
Social content (t+1)		
Others (t+1)		-0.062 (0.085)
Self (t+1)		0.066 (0.099)
Temporal content (t+1)		
Past (t+1)		0.051 (0.100)
Future (t+1)		-0.089 (0.085)
N. of observations (entries)	15948	10675
N. of entities	522	4269
F-test	139.98	24.465
R²	0.1249	0.1063

Table A2.2: Regression coefficients, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models predicting experienced worthwhileness including time lags for (2) t+1

Results of logistic regressions using valence of thoughts as dependent variable

We run a series of fixed effects logistic regressions, using dummies of valence of thought variables as the dependent variable, on the 29435 unique reports of thoughts. For each of these regressions, the model automatically drops all entities (in this case, participants) that did not report any variation in these respective dependent variables. This corresponds to 3304 reports (109 participants) of negative valence and 523 reports (46 participants) of positive valence, resulting in sample sizes of 29045, 26131 and 28912 observations, respectively. Results for positive and negative valence are reported in the table below.

Dependent variable	(1)	(2)
TUT	2.599*** (.177)	1.528*** (.075)
Social content		
Others	2.629*** (.183)	.517*** (.031)
Self	.843* (.072)	1.665*** (.111)
Temporal content		
Past	2.695*** (.220)	.469*** (.033)
Future	1.071 (.077)	.727*** (.043)
N. of observations (thoughts)	26,131	28,912
N. of entities (individuals)	422	485
Pseudo-R^2	0.0926	0.0197

Table A2.3: Odds ratios, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of logistic fixed effects models predicting the probability of reporting (1) a negative valence and (2) a positive valence using type and content of thought as independent variables.

We observe that reporting a TUT makes it over two and a half times more likely that the thought will be negative, and only slightly more likely that it will be positive. We further see that reporting thoughts about other people makes it more likely that the thoughts will be negative, and less likely for it to be positive. The opposite can be said of thoughts about self. In general, any kind of temporal thought makes it less likely for the thought to be positive (as opposed to when temporal content is not specified, but no such effect is found for the likelihood of reporting a negative thought. That being said, past-related thoughts also make it significantly more likely to be a negative thought.

We also note that the pseudo-R^2 values suggest that type and content of thoughts are better predictors of negative thoughts, relative to positive ones. A possible explanation for this could be that reports of negative valence are more commonly associated with internal processes, while reports of positive valence depend more on external stimuli.

Comparison of thoughts & activities

We run three fixed effects models on experienced happiness and worthwhileness, (1) with activities only, (2) with company only, and (3) with both activities and company, including interaction effects. We find that activities alone explain 5.33% of experienced happiness and 7.76% of experienced worthwhileness, while company alone explains 4.70% and 3.50%, respectively. Coefficients, significance levels and clustered standard errors are reported in the tables below.

DV: Experienced happiness	(1)	(2)	(3)
Activity			
Studying	-0.283*** (0.046)		-0.303** (0.115)
Eating/drinking	0.255*** (0.032)		0.213* (0.094)
Working	-0.258*** (0.059)		-0.338* (0.151)
Commuting/travelling	-0.183*** (0.044)		-0.176 (0.109)
Socialising	0.591*** (0.046)		0.366** (0.118)
Watching TV	0.095 (0.050)		0.058 (0.149)
Social media	-0.281*** (0.052)		-0.131 (0.127)
Browsing internet	-0.161* (0.075)		-0.175 (0.173)
Rest	-0.084 (0.076)		0.759* (0.319)
Exercise	0.517*** (0.072)		0.534** (0.173)
Self-care/grooming	-0.042 (0.071)		0.087 (0.254)
Shopping/errands	0.042 (0.088)		0.187 (0.359)
Other	0.146 (0.122)		0.380** (0.137)
Cooking	0.251*** (0.066)		0.282 (0.202)
Reading	0.067 (0.111)		0.039 (0.315)
Listening to music	0.216 (0.128)		-0.022 (0.294)
Relaxing/nothing special	-0.200 (0.152)		-0.154 (0.152)
Housework	-0.240* (0.107)		-0.168 (0.109)
Playing	0.811*** (0.220)		0.806*** (0.218)
Walking	0.466** (0.178)		0.468 (0.807)
Childcare	0.112 (0.354)		-0.124 (0.322)
Listening to radio	0.176 (0.152)		0.326* (0.154)
Worship/meditation	0.158 (0.344)		0.123 (0.302)
Company			
Alone		-0.311*** (0.050)	-0.262** (0.099)
Friends		0.417*** (0.047)	0.391*** (0.094)
Colleagues		-0.208*** (0.051)	-0.176 (0.114)
Partner		0.433*** (0.076)	0.490*** (0.144)
Family		0.311*** (0.084)	0.272 (0.143)
Strangers		-0.117 (0.060)	-0.148 (0.123)
Interactions			
Studying * Friends			-0.216* (0.091)
Studying * Colleagues			0.261* (0.119)
Working * Colleagues			0.287* (0.138)
Working * Partner			-0.408* (0.200)
Watching TV * Strangers			0.876** (0.276)
Social media * Peers			0.592*** (0.157)
Rest * Alone			-0.687* (0.317)
Exercise * Strangers			0.475* (0.197)
Self-care/grooming * Colleagues			0.472* (0.231)
Other * Alone			-0.560** (0.215)
N. of observations (entries)	15901	15901	15901
N. of entities (individuals)	524	524	524
F-test	37.573	75.730	11.570
R^2	0.0533	0.0470	0.0872

Table A2.4: Regression coefficients, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models predicting experienced happiness using activities and company as independent variables.

DV: Experienced worthwhileness	(1)	(2)	(3)
Activity			
Studying	0.448*** (0.062)		0.432*** (0.127)
Eating/drinking	0.152*** (0.039)		0.256** (0.097)
Working	0.210** (0.079)		0.185 (0.156)
Commuting/travelling	-0.245*** (0.051)		-0.362** (0.121)
Socialising	0.618*** (0.051)		0.422** (0.132)
Watching TV	-0.549*** (0.066)		-0.702*** (0.184)
Social media	-0.786*** (0.073)		-0.842*** (0.189)
Browsing internet	-0.382*** (0.086)		-0.442* (0.182)
Rest	-0.099 (0.098)		0.510 (0.376)
Exercise	0.923*** (0.096)		1.137*** (0.221)
Self-care/grooming	0.266** (0.084)		0.635* (0.298)
Shopping/errands	0.141 (0.087)		0.200 (0.410)
Other	0.534** (0.166)		0.467** (0.163)
Cooking	0.345*** (0.089)		0.235 (0.197)
Reading	0.208 (0.128)		0.766** (0.289)
Listening to music	0.065 (0.128)		-0.036 (0.362)
Relaxing/nothing special	-0.579** (0.187)		-0.553** (0.185)
Housework	0.365** (0.134)		0.445** (0.139)
Playing	-0.111 (0.256)		-0.079 (0.246)
Walking	0.187 (0.182)		0.135 (0.210)
Childcare	0.805 (0.489)		0.458 (0.433)
Listening to radio	0.131 (0.200)		0.293 (0.203)
Worship/meditation	1.438*** (0.303)		1.343*** (0.290)
Company			
Alone		-0.292*** (0.054)	-0.301** (0.115)
Friends		0.379*** (0.057)	0.316** (0.116)
Colleagues		0.193** (0.064)	0.050 (0.133)
Partner		0.240** (0.0913)	0.314* (0.157)
Family		0.451*** (0.103)	0.523** (0.171)
Strangers		0.228** (0.072)	0.256 (0.145)
Interactions			
Studying * Friends			-0.323** (0.109)
Commuting/travelling * Colleagues			0.284* (0.127)
Commuting/travelling * Strangers			-0.363* (0.171)
Watching TV * Strangers			1.495*** (0.269)
Social media * Colleagues			0.913*** (0.223)
Social media * Peers			1.761** (0.617)
Browsing internet * Colleagues			0.518** (0.188)
Rest * Family			-1.028* (0.474)
Self-care/grooming * Family			-0.903* (0.389)
Reading * Colleagues			-0.887** (0.333)
Listening to music * Partner			0.955** (0.350)
N. of observations (entries)	15948	15948	15948
N. of entities (individuals)	522	522	522
F-test	56.325	55.922	14.878
R²	0.0776	0.0350	0.1045

Table A2.5: Regression coefficients, significance (*: p<0.05, **: p<0.01, ***: p<0.001) and clustered standard errors (in parentheses) of fixed effects models predicting experienced happiness using activities and company as independent variables.

While we are mainly interested in the explanatory power of activities relative to that of thoughts, we observe large variations in the magnitude of coefficients depending on the activity, which suggests that, while the explanatory power of activities is lower than that of thoughts, activities still play an important role in explaining experienced well-being, particularly when it comes to activities that are reported commonly, such as studying, social media, or exercise.

In addition, we see that the company that people report alongside their activity can drastically change the way this activity is perceived in terms of well-being. For instance, the effect of social media appears to be generally negative (b=-0.842, p<0.001), but this effect is reversed when people report being in the company of colleagues (b=0.913, p<0.001). As such, the interaction between what we do and who we do it with may be of interest to researchers interested in how our daily activities make us feel.

A3. Supplementary materials: chapter 4

Result tables

Tables A3.1 – A3.4: Step-by-step mixed effect multi-level regressions on happiness (DV) including (1) thought and personality variables with random slopes for thought variables, and (2) significant interactions between thought and personality variables. DV and personality variables are standardised (mean = 0, SD = 1).

Happiness						
	Coef.	SE	P-value	Coef.	SE	P-value
TUT				-0.057	0.014	0.000
Intercept	0.004	0.032	0.909	0.028	0.032	0.390
Random effects						
Intercept	0.431	0.030		0.430	0.030	
Residual	0.544	0.006		0.543	0.006	
Number of obs	15029			15029		
Number of groups	477			477		
Log likelihood	-17454.85			-17446.774		

Table A3.1

Happiness	

	Coef.	SE	P-value
TUT	-0.058	0.022	0.008
Intercept	0.031	0.032	0.337
Random effects *User*			
TUT	0.097	0.013	
Intercept	0.420	0.031	
Residual	0.526	0.006	
Number of obs	15029		
Number of groups	477		
Log likelihood	-17356.323		

Table A3.2

Happiness						
	Coef.	SE	P-value	Coef.	SE	P-value
TUT	-0.028	0.022	0.204	-0.022	0.024	0.361
Social						
Self	-0.036	0.023	0.122	-0.037	0.027	0.182
Others	0.045	0.022	0.037	0.038	0.027	0.163
Temporal						
Past	-0.011	0.023	0.636	-0.022	0.033	0.508
Future	-0.019	0.022	0.399	-0.030	0.027	0.272
Valence						
Negative	-0.560	0.019	0.000	-0.560	0.019	0.000
Positive	0.549	0.013	0.000	0.548	0.013	0.000
Intercept	-0.206	0.030	0.000	-0.205	0.029	0.000
Random effects *User*						
TUT	0.057	0.009		0.062	0.015	
Self				0.038	0.016	
Others				0.049	0.017	
Past				0.128	0.028	
Future				0.048	0.018	
Intercept	0.338	0.025		0.336	0.025	
Residual	0.419	0.005		0.405	0.005	

Number of obs	15029			15029		
Number of groups	477			477		
Log likelihood	-15611.206			-15551.793		

Table A3.3

Happiness						
	Coef.	SE	P-value	Coef.	SE	P-value
TUT	-0.023	0.024	0.347	-0.024	0.024	0.318
Social						
Self	-0.035	0.027	0.198	-0.033	0.027	0.217
Others	0.037	0.027	0.167	0.037	0.027	0.176
Temporal						
Past	-0.022	0.033	0.499	-0.019	0.033	0.571
Future	-0.030	0.027	0.279	-0.026	0.027	0.330
Valence						
Negative	-0.557	0.019	0.000	-0.558	0.019	0.000
Positive	0.546	0.013	0.000	0.546	0.013	0.000
Agreeableness	0.043	0.026	0.105	0.045	0.028	0.099
Conscientiousness	0.070	0.026	0.007	0.076	0.027	0.005
Extroversion	0.055	0.028	0.050	0.062	0.029	0.033
Openness	-0.022	0.027	0.425	-0.026	0.028	0.355
Stability	0.136	0.026	0.000	0.137	0.027	0.000
Interactions						
Agr*Fut				-0.056	0.027	0.039
Intercept	-0.205	0.028	0.000	-0.205	0.028	0.000
Random effects						
User						
TUT	0.062	0.015		0.061	0.015	
Self	0.039	0.017		0.033	0.016	
Others	0.049	0.017		0.047	0.017	
Past	0.129	0.028		0.123	0.028	
Future	0.051	0.018		0.038	0.017	
Intercept	0.295	0.022		0.294	0.022	
Residual	0.405	0.005		0.406	0.005	
Number of obs	15029			15029		
Number of groups	477			477		
Log likelihood	-15525.554			-15511.156		

Table A3.4

Tables A3.5 - A3.7: Step-by-step mixed effect multi-level regressions on worthwhileness (DV) including (1) thought and personality variables with random slopes for thought variables. DV and personality variables are standardised (mean = 0, SD = 1).

Worthwhileness	Coef.	SE	P-value	Coef.	SE	P-value
TUT				-0.065	0.014	0.000
Intercept	0.009	0.031	0.767	0.036	0.031	0.246
Random effects *User*						
Intercept	0.406	0.029		0.405	0.029	
Residual	0.558	0.007		0.557	0.007	
Number of obs	15084			15084		
Number of groups	477			477		
Log likelihood	-17684.204			-17673.848		

Table A3.5

Worthwhileness	Coef.	SE	P-value	Coef.	SE	P-value
TUT	-0.063	0.020	0.001	-0.059	0.023	0.013
Social						
Self				0.029	0.025	0.258
Others				0.003	0.023	0.893
Temporal						
Past				0.000	0.025	0.988
Future				0.000	0.024	0.993
Valence						
Negative				-0.371	0.020	0.000
Positive				0.410	0.014	0.000
Intercept	0.037	0.031	0.237	-0.147	0.030	0.000
Random effects *User*						
TUT	0.064	0.011		0.054	0.009	
Intercept	0.396	0.029		0.332	0.025	

Residual	0.545	0.006	0.492	0.006
Number of obs	15084		15084	
Number of groups	477		477	
Log likelihood	-17625.014		-16834.772	

Table A3.6

Worthwhileness			
	Coef.	SE	P-value
TUT	-0.061	0.028	0.027
Social			
Self	0.052	0.032	0.108
Others	0.007	0.030	0.827
Temporal			
Past	-0.003	0.033	0.931
Future	-0.015	0.029	0.599
Valence			
Negative	-0.368	0.020	0.000
Positive	0.407	0.014	0.000
Intercept	-0.147	0.030	0.000
Random effects			
User			
TUT	0.103	0.019	
Self	0.091	0.025	
Others	0.067	0.022	
Past	0.097	0.027	
Future	0.052	0.018	
Intercept	0.333	0.025	
Residual	0.476	0.006	
Number of obs	15084		
Number of groups	477		
Log likelihood	-16771.743		

Table A3.7

Additional individual-specific characteristics

We find no significant interactions between type and content of thoughts and gender or age. Aside from personality, we ran the same set of multi-level models including random

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slopes using other individual-specific characteristics, including self-esteem, optimism, attitude towards uncertainty and sense of control.

Self-esteem. Self-esteem was captured using a one-dimensional 10-item scale, using the Rosenberg Self-Esteem Scale (Rosenberg, 1965). Items are scored on a 4-point scale ranging from *Strongly disagree* to *Strongly agree*. This scale has been widely used in psychological literature since its conception and has shown good validity and reliability across different samples and contexts (Donnellan et al., 2015; Schmitt & Allik, 2005). The self-esteem score will be computed by adding up scores of all 10 items and standardised (mean = 0, SD = 1).

Results. Self-esteem had the strongest effect on well-being (β = 0.251, p < 0.001 for happiness, β = 0.245, p < 0.001 for worthwhileness) of all individual-specific characteristics that were measured as part of the study. Despite a few significant interaction terms, interaction models showed no significant improvement upon the models with interactions for either happiness ($\chi^2(5)$ = 8.66, p = 0.123) or worthwhileness ($\chi^2(5)$ = 7.534, p = 0.184).

Optimism. We measured optimism using the revised version of the Life Orientation Test as proposed by Scheier et al. (1994). The scale is composed of 6 items and is measured on a 5-point scale ranging from *Strongly disagree* to *Strongly agree*. Item scores were added up to form a single optimism score which was then standardised (mean = 0, SD = 1).

Results. Optimism had a strong significant effect on well-being (β = 0.203, p < 0.001 for happiness, β = 0.172, p < 0.001 for worthwhileness). The interaction models showed no significant improvement upon the models with interactions for either happiness ($\chi^2(5)$ = 3.418, p = 0.636) or worthwhileness ($\chi^2(5)$ = 4.518, p = 0.477).

Attitude towards uncertainty. Attitude towards uncertainty was measured according to two dimensions: prospective anxiety and inhibitory anxiety, using the 12-item version of the Intolerance of Uncertainty scale (Buhr & Dugas, 2002) as proposed by Carleton et al. (2007). The scale includes 7 items that load onto the prospective anxiety dimension, and 5 that load onto inhibitory anxiety. Items were scored on a 5-point scale, ranging from *Not at all characteristic of me* to *Entirely characteristic of me*. Scores for both factors were computed by adding up the scores of the relevant items and were standardised (mean = 0, SD = 1).

Results. Only inhibitory anxiety had a significant effect on experienced well-being (β = -0.126, p < 0.001 for happiness, β = -0.107, p = 0.001 for worthwhileness). Interaction models showed a significant improvement over models without interactions for both

happiness (χ^2(10) = 19.178, p = 0.038) and worthwhileness (χ^2(10) = 19.968, p = 0.030). In the happiness models, we see that a 1 SD increase in prospective anxiety is associated with a 0.090 SD increase in happiness when participants are thinking about the past (p = 0.048). In the worthwhileness models, we find that a 1 SD increase in inhibitory anxiety is associated with a 0.091 SD decrease in worthwhileness when thinking about others (p = 0.017). No interaction coefficients were significant after applying the False Discovery Rate correction.

Sense of control. We measured sense of control according to two dimensions: personal mastery and perceived constraints, using Lachman & Weaver's (1998) sense of control scale. The scale contains 12 items, of which 4 load onto the personal mastery factor, and 8 on the perceived constraints factor. While various ranges of Likert scales have been used to capture sense of control, the present study uses a 7-point scale, ranging from *Strongly disagree* to *Strongly agree*, as this scale showed the highest level of internal consistency in the original study. Scores for both factors were computed by adding up the scores of the relevant items and were standardised (mean = 0, SD = 1).

Results. Only perceived constraints had a significant effect on experienced well-being (β = -0.140, p < 0.001 for happiness, β = -0.123, p < 0.001 for worthwhileness). The interaction model showed a significant improvement upon the model without interactions for happiness (χ^2(10) = 20.632, p = 0.024), but not worthwhileness (χ^2(10) = 10.062, p = 0.435). A 1 SD increase in perceived constraints was associated with a 0.071 SD decrease in happiness when people were thinking about themselves (p = 0.048). No interaction coefficients were significant after applying the False Discovery Rate correction.

Pleasure-purpose balance. We asked all participants their current and ideal balance between pleasure and purpose, on a sliding scale of 1 to 100, where 50 indicates that the participant values pleasure and purpose equally, and a higher score indicates greater emphasis on purpose. Participants were shown a horizontal slider without numerical values, so as not to create an association between higher values and either pleasure or purpose. Scores gathered for this question were standardised (mean = 0, SD = 1) like the rest of the individual-specific variables.

Results. Neither current nor ideal pleasure-purpose balance had a significant effect on reported well-being. Interactions between thoughts and current balance did not significantly predict happiness (χ^2(5) = 6.644, p = 0.248) or worthwhileness (χ^2(5) = 6.276, p = 0.280) better than the model without interactions. Interactions between thoughts and ideal balance predicted happiness significantly better than the model without interactions (χ^2(5) = 17.278, p = 0.004), but not worthwhileness (χ^2(5) = 7.878, p = 0.163). A 1 SD shift towards purpose is

associated with a 0.090 SD increase in happiness when people were thinking about the past (p = 0.031). No interaction coefficients were significant after applying the False Discovery Rate correction.

A4. Supplementary materials: chapter 5

Full list of activities and company

	Total obs	Happiness	Happiness obs	Wwhileness	Wwhileness obs
All	21,721	6.337847	15,877	6.346917	15,926
Studying	5,685	6.116738	4,463	6.529663	4,450
Eating/drinking	4,491	6.633775	3,547	6.373824	3,614
Working	2,936	6.12252	2,016	6.550791	1,959
Commuting/travelling	2,706	6.187981	2,080	6.126576	2,141
Socialising	2,491	7.02496	1,883	6.946549	1,927
Watching TV	2,033	6.227995	1,636	5.444238	1,614
Social media	1,819	5.899209	1,518	5.255599	1,518
Browsing internet	1,275	6.221198	868	6.169126	881
Rest	1,268	6.173604	985	6.006	1,000
Exercising	712	7.058615	563	7.369176	558
Self-care/grooming	596	6.331683	404	6.609453	402
Shopping/errands	504	6.455621	338	6.58046	348
Other	511	6.312977	393	6.730673	401
Cooking	513	6.79798	396	6.848718	390
Reading	487	6.494845	291	6.35	280
Listening to music	435	6.737778	225	6.909465	243
Relaxing/nothing special	375	6.225664	226	5.731092	238
Housework	341	6.097122	278	6.702899	276
Playing	203	7.340909	132	6.381679	131
Walking	130	7.056818	88	6.602151	93
Childcare	115	6.561798	89	7.085106	94
Listening to the radio	66	7	47	7.113636	44
Worship/meditation	63	6.378378	37	8.06	50
Making love	5	9.4	5	7.333333	3

Table A4.1: Full list of activities reported across all EMA entries, including average happiness and worthwhileness reports. Activities for analysis were selected based on subsamples of happiness and worthwhileness reports.

	Total obs	Happiness	Happiness obs	Worthwhileness	Worthwhileness obs
All	21,721	6.337847	15,877	6.346917	15,926
Alone	12039	6.104707	8796	6.062924	8836
Friends	4955	6.83261	3686	6.744248	3781
Colleagues	3046	6.30121	2231	6.619069	2234

Partner	1845	6.803571	1456	6.626771	1412
Family	1386	6.688761	1041	6.923226	1029
Strangers	1373	6.110136	1026	6.505848	1026
Peers	196	6.576642	137	7.208333	144
Academic staff	77	6.55102	49	7.384615	65
Other	22	6.0625	16	7.571429	14

Table A4.2: Full list of types of company reported across all EMA entries, including average happiness and worthwhileness reports. Types of company for analysis were selected based on subsamples of happiness and worthwhileness reports.

Result tables

	TUT	Negative thoughts	Positive thoughts
Studying	-0.071*** (0.008)	0.034*** (0.006)	-0.039*** (0.008)
Eating/drinking	0.117*** (0.008)	-0.017** (0.006)	0.115*** (0.008)
Working	-0.120*** (0.010)	0.008 (0.008)	-0.086*** (0.010)
Commuting	0.113*** (0.009)	0.037*** (0.007)	-0.011 (0.010)
Socialising	0.076*** (0.01)	-0.013 (0.007)	0.206*** (0.010)
Watching TV	-0.033** (0.011)	0.012 (0.008)	0.045*** (0.011)
Social media	0.070*** (0.011)	0.033*** (0.009)	-0.057*** (0.012)
C	0.370*** (0.005)	0.124*** (0.004)	0.536*** (0.006)
N	21,721	21,721	21,721
Ind	531	531	531

Table A4.3: Fixed effects linear probability models predicting TUT and positive and negative thoughts, using activities as independent variables. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

	TUT	Negative thoughts	Positive thoughts
Alone	0.05*** (0.01)	0.041*** (0.008)	-0.073*** (0.01)
Friends	0.059*** (0.01)	-0.006 (0.008)	0.149*** (0.01)
Colleagues	-0.066*** (0.011)	0.013 (0.008)	-0.049*** (0.011)
Partner	0.127*** (0.014)	-0.009 (0.01)	0.139*** (0.014)
Family	0.112*** (0.015)	0.012 (0.011)	0.101*** (0.015)
Strangers	0.023 (0.013)	0.028** (0.01)	0.021 (0.014)
C	0.333*** (0.01)	0.112*** (0.008)	0.554*** (0.01)
N	21,721	21,721	21,721
Ind	531	531	531

Table A4.4: Fixed effects linear probability models predicting TUT and positive and negative thoughts, using types of company as independent variables. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

	Others	Self	Past	Future
Studying	-0.01 (0.013)	0.085*** (0.014)	-0.02 (0.012)	0.123*** (0.014)
Eating/drinking	0.027* (0.011)	-0.039*** (0.012)	-0.016 (0.011)	-0.048*** (0.013)
Working	-0.071*** (0.017)	0.082*** (0.019)	0.027 (0.017)	0.151*** (0.019)

Commuting	0.017 (0.013)	-0.001 (0.014)	0.048*** (0.013)	0.022 (0.015)
Socialising	0.162*** (0.013)	0.01 (0.015)	0.078*** (0.013)	-0.005 (0.015)
Watching TV	0.019 (0.017)	-0.022 (0.018)	-0.014 (0.016)	-0.004 (0.019)
Social media	0.056*** (0.016)	0.009 (0.018)	0.028 (0.016)	0.066*** (0.019)
C	0.247*** (0.008)	0.33*** (0.009)	0.214*** (0.008)	0.416*** (0.009)
N	8,355	8,355	8,355	8,355
Ind	513	513	513	513

Table A4.5: Fixed effects linear probability models predicting social and temporal content of TUT, using activities as independent variables, on the sub-sample of EMA entries that included a report of TUT. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

	Others	Self	Past	Future
Alone	-0.012 (0.015)	0.026 (0.016)	-0.013 (0.015)	0.086*** (0.017)
Friends	0.122*** (0.015)	-0.016 (0.016)	-0.009 (0.015)	-0.006 (0.017)
Colleagues	-0.06*** (0.017)	0.052** (0.019)	0.028 (0.017)	0.124*** (0.02)
Partner	0.192*** (0.019)	-0.056** (0.02)	-0.003 (0.018)	-0.055* (0.021)
Family	0.028 (0.021)	-0.017 (0.023)	-0.003 (0.02)	0.008 (0.024)
Strangers	-0.033 (0.019)	0.088*** (0.021)	0.031 (0.019)	0.057** (0.022)
C	0.242*** (0.015)	0.331*** (0.016)	0.234*** (0.015)	0.396*** (0.017)
N	8,355	8,355	8,355	8,355
Ind	513	513	513	513

Table A4.6: Fixed effects linear probability models predicting social and temporal content of TUT, using types of company as independent variables, on the sub-sample of EMA entries that included a report of TUT. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

	General	Alone	Friends	Colleagues
TUT	-0.011 (0.018)	-0.039 (0.024)	-0.066 (0.035)	-0.028 (0.057)
Valence				
Negative	-0.623*** (0.018)	-0.6*** (0.023)	-0.598*** (0.038)	-0.575*** (0.048)
Positive	0.605*** (0.013)	0.531*** (0.017)	0.587*** (0.027)	0.424*** (0.035)
Content				
Self	-0.02 (0.022)	-0.066* (0.028)	0.095* (0.046)	0.172** (0.065)
Others	0.042* (0.021)	0.012 (0.029)	0.088* (0.038)	0.042 (0.064)
Past	-0.04 (0.022)	-0.078** (0.03)	0.087* (0.042)	0.051 (0.062)
Future	-0.017 (0.021)	0.033 (0.027)	-0.107* (0.044)	-0.109 (0.066)
C	-0.246*** (0.01)	-0.262*** (0.012)	-0.075*** (0.023)	-0.18*** (0.025)
N	15876	8795	3686	2231
Ind.	524	486	416	371
F	753.79	364.30	150.07	57.58
R^2	0.2559	0.2350	0.2435	0.1787

Table A4.7: Fixed effects regressions using thought variables (independent variables) to predict reported happiness (dependent variable) in general and by company. Standard errors are clustered on an individual level. *: p < 0.05, **: p < 0.01, ***: p < 0.001.

	Partner	Family	Strangers
TUT	0.168** (0.06)	-0.022 (0.072)	-0.074 (0.097)
Valence			
Negative	-0.771*** (0.066)	-0.509*** (0.07)	-0.589*** (0.077)
Positive	0.701*** (0.049)	0.594*** (0.056)	0.457*** (0.064)
Content			
Self	-0.056 (0.084)	0.014 (0.077)	0.021 (0.093)
Others	-0.12* (0.059)	0.043 (0.076)	-0.06 (0.093)
Past	-0.111 (0.071)	0.059 (0.083)	0.064 (0.091)
Future	-0.074 (0.079)	-0.042 (0.073)	0.141 (0.096)
C	-0.2*** (0.045)	-0.156** (0.051)	-0.295*** (0.053)
N	1456	1041	1026
Ind.	201	216	283
F	77.64	31.64	24.53
R^2	0.3034	0.2131	0.1864

Table A4.7 (con'd): Fixed effects regressions using thought variables (independent variables) to predict reported happiness (dependent variable) in general and by company. Standard errors are clustered on an individual level. *: p < 0.05, **: p < 0.01, ***: p < 0.001.

	General	Studying	Eating/drinking	Working
TUT	-0.064*** (0.02)	-0.132*** (0.038)	-0.036 (0.035)	-0.1 (0.065)
Valence				
Negative	-0.417*** (0.02)	-0.358*** (0.031)	-0.36*** (0.039)	-0.363*** (0.048)
Positive	0.448*** (0.014)	0.338*** (0.024)	0.433*** (0.029)	0.355*** (0.036)
Content				
Self	0.069** (0.025)	0.026 (0.043)	0.078 (0.043)	0.02 (0.07)
Others	0.015 (0.023)	-0.012 (0.041)	0.007 (0.038)	-0.051 (0.069)
Past	-0.014 (0.024)	-0.013 (0.045)	0.033 (0.042)	0.124 (0.066)
Future	-0.019 (0.024)	0.041 (0.042)	-0.045 (0.04)	-0.021 (0.075)
C	-0.175*** (0.011)	-0.001 (0.017)	-0.215*** (0.024)	-0.01 (0.025)
N	15924	4450	3614	1959
Ind.	522	391	443	327
F	302.93	72.96	58.75	32.73
R^2	0.1211	0.1119	0.1150	0.1236

Table A4.8: Fixed effects regressions using thought variables (independent variables) to predict reported worthwhileness (dependent variable) in general and by activity. Standard errors are clustered on an individual level. *: p < 0.05, **: p < 0.01, ***: p < 0.001.

	Commuting	Socialising	Watching TV	Social media
TUT	0.118* (0.05)	-0.015 (0.052)	0.052 (0.065)	-0.098 (0.072)
Valence				
Negative	-0.536*** (0.049)	-0.335*** (0.054)	-0.284*** (0.068)	-0.351*** (0.067)
Positive	0.327*** (0.039)	0.516*** (0.045)	0.371*** (0.048)	0.444*** (0.053)
Content				
Self	0.051 (0.058)	0.155* (0.062)	0.016 (0.08)	0.013 (0.075)
Others	-0.051 (0.056)	0.086 (0.05)	-0.019 (0.074)	0.15* (0.072)
Past	-0.064 (0.056)	-0.061 (0.053)	-0.074 (0.078)	-0.099 (0.077)
Future	-0.101 (0.056)	-0.031 (0.06)	0.06 (0.075)	0.106 (0.073)
C	-0.219*** (0.029)	-0.1* (0.042)	-0.605*** (0.037)	-0.641*** (0.037)
N	2141	1927	1614	1518
Ind.	411	380	331	292
F	37.27	37.56	15.34	22.57
R^2	0.1315	0.1458	0.0776	0.1148

*Table A4.8 (con'd): Fixed effects regressions using thought variables (independent variables) to predict reported worthwhileness (dependent variable) in general and by activity. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.*

	General	Alone	Friends	Colleagues
TUT	-0.064*** (0.02)	-0.081** (0.027)	-0.117*** (0.036)	-0.106 (0.058)
Valence				
Negative	-0.417*** (0.02)	-0.413*** (0.026)	-0.374*** (0.039)	-0.373*** (0.049)
Positive	0.448*** (0.014)	0.381*** (0.02)	0.39*** (0.028)	0.399*** (0.036)
Content				
Self	0.069** (0.025)	0.038 (0.032)	0.192*** (0.048)	0.083 (0.066)
Others	0.015 (0.023)	-0.052 (0.034)	0.054 (0.04)	0.041 (0.065)
Past	-0.014 (0.024)	-0.013 (0.034)	0.002 (0.044)	0.018 (0.063)
Future	-0.019 (0.024)	0.027 (0.031)	-0.061 (0.046)	-0.093 (0.066)
C	-0.175*** (0.011)	-0.224*** (0.014)	-0.02 (0.024)	-0.013*** (0.026)
N	15924	8835	3781	2234
Ind.	522	489	417	367
F	302.93	129.30	60.16	37.92
R^2	0.1211	0.0979	0.1115	0.1249

*Table A4.9: Fixed effects regressions using thought variables (independent variables) to predict reported worthwhileness (dependent variable) in general and by company. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.*

	Partner	Family	Strangers
TUT	0.086 (0.066)	0.181* (0.072)	-0.127 (0.098)
Valence			

Negative	-0.642*** (0.072)	-0.373*** (0.072)	-0.402*** (0.083)
Positive	0.469*** (0.054)	0.341*** (0.059)	0.445*** (0.067)
Content			
Self	0.091 (0.09)	-0.072 (0.08)	0.16 (0.099)
Others	-0.041 (0.064)	0.027 (0.076)	0.041 (0.098)
Past	-0.16* (0.074)	-0.025 (0.081)	-0.085 (0.093)
Future	-0.018 (0.084)	0.008 (0.075)	-0.012 (0.101)
C	-0.154** (0.048)	-0.011 (0.053)	-0.098 (0.054)
N	1411	1029	1026
Ind.	198	204	283
F	34.38	13.67	14.94
R^2	0.1663	0.1047	0.1232

*Table A4.9 (con'd): Fixed effects regressions using thought variables (independent variables) to predict reported worthwhileness (dependent variable) in general and by company. Standard errors are clustered on an individual level. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.*

A5. Supplementary materials: chapter 6

Main results

A. Study 1

	Treatment				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	7.03	7.1	0.07	**0.42663**	273
Worthwhileness	7.26	7.39	0.13	**0.21763**	272
Happiness yesterday	6.95	7.17	0.22	**0.16173**	273
Anxiety yesterday	5.56	4.86	-0.7	**0.00426**	272
Happiness in general	7.22	7.43	0.21	**0.0727**	273
Anxiety in general	5.71	5.27	-0.44	**0.06072**	273

Table A5.1: Within-sample difference between onboarding and exit questionnaire for well-being measures in the treatment group in study 1.

	Control				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	7.15	7.08	-0.07	**0.87286**	122
Worthwhileness	7.38	7.57	0.19	**0.37862**	122
Happiness yesterday	7.43	7.12	-0.31	**0.38112**	122
Anxiety yesterday	5.21	5.47	0.26	**0.42348**	122

Happiness in general	7.27	7.41	0.14	**0.41552**	122
Anxiety in general	5.22	5.48	0.26	**0.45328**	122

Table A5.2: Within-sample difference between onboarding and exit questionnaire for well-being measures in the control group in study 1.

	Treatment effect		
Mann-Whitney	**Difference**	**P (two-sided)**	**Cohen's *d***
Life satisfaction	0.14	**0.25286**	0.09
Worthwhileness	-0.06	**0.92776**	0.03
Happiness yesterday	0.53	**0.0707**	0.26
Anxiety yesterday	-0.96	**0.00222**	0.36
Happiness in general	0.07	**0.3714**	0.04
Anxiety in general	-0.7	**0.01428**	0.30

Table A5.3: Between-sample difference between onboarding and exit questionnaire for well-being measures in study 1 (treatment effect).

B. Study 2

	Treatment				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	6.79	6.73	-0.06	**0.99534**	255
Worthwhileness	7.09	6.91	-0.18	**0.3007**	253
Happiness yesterday	6.58	6.71	0.13	**0.31294**	252
Anxiety yesterday	4.86	4.5	-0.36	**0.12146**	255
Happiness in general	6.78	6.82	0.04	**0.56686**	253
Anxiety in general	5.17	4.67	-0.5	**0.01656**	255

Table A5.4: Within-sample difference between onboarding and exit questionnaire for well-being measures in the treatment group in study 2.

	Control				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	6.89	6.51	-0.38	**0.14538**	93
Worthwhileness	6.84	6.77	-0.07	**0.88188**	92
Happiness yesterday	6.6	6.19	-0.41	**0.25248**	93

Anxiety yesterday	5.18	5.08	-0.1	**0.79112**	93
Happiness in general	6.77	6.57	-0.2	**0.48244**	93
Anxiety in general	5.52	5.44	-0.08	**0.97056**	91

Table A5.5: Within-sample difference between onboarding and exit questionnaire for well-being measures in the control group in study 2.

	Treatment effect		
Mann-Whitney	**Difference**	**P (two-sided)**	**Cohen's *d***
Life satisfaction	0.32	**0.1085**	0.20
Worthwhileness	-0.11	**0.82106**	0.06
Happiness yesterday	0.54	**0.0812**	0.27
Anxiety yesterday	-0.26	**0.6055**	0.10
Happiness in general	0.24	**0.17726**	0.15
Anxiety in general	-0.42	**0.037**	0.18

Table A5.6: Between-sample difference between onboarding and exit questionnaire for well-being measures in study 2 (treatment effect).

C. Study 3

	Treatment				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	6.5	7.1	0.6	**0.02064**	82
Worthwhileness	6.64	6.87	0.23	**0.51118**	83
Happiness yesterday	6.12	6.7	0.58	**0.02568**	83
Anxiety yesterday	5.71	5.45	-0.26	**0.59252**	84
Happiness in general	6.54	6.79	0.25	**0.36622**	84
Anxiety in general	5.73	5.67	-0.06	**0.86112**	84
GAD-7	8.66	6.79	-1.87	**0.02714**	82
PSS-10	21.59	19.3	-2.29	**0.02234**	80
PHQ-8	9.48	7.85	-1.63	**0.05314**	79
WHO-5	44.14	48.14	4	**0.31056**	84

Table A5.7: Within-sample difference between onboarding and exit questionnaire for well-being measures in the treatment group in study 3.

	Control				
Mann-Whitney	**Mean onb**	**Mean exit**	**Diff**	**P (two-sided)**	**N**
Life satisfaction	6.5	6.78	0.28	**0.3113**	125
Worthwhileness	6.63	6.61	-0.02	**0.5878**	126
Happiness yesterday	5.94	6.5	0.56	**0.0694**	129
Anxiety yesterday	5.56	5.13	-0.43	**0.16266**	127
Happiness in general	6.19	6.39	0.2	**0.27734**	129
Anxiety in general	5.61	5.62	0.01	**0.92918**	128
GAD-7	8.35	8.07	-0.28	**0.62128**	124
PSS-10	20.75	19.01	-1.74	**0.07566**	119
PHQ-8	9.2	8.22	-0.98	**0.15628**	123
WHO-5	43.07	46.64	3.57	**0.17274**	129

Table A5.8: Within-sample difference between onboarding and exit questionnaire for well-being measures in the control group in study 3.

	Treatment effect		
Mann-Whitney	**Difference**	**P (two-sided)**	**Cohen's *d***
Life satisfaction	0.32	**0.06182**	0.18
Worthwhileness	0.25	**0.17072**	0.13
Happiness yesterday	0.02	**0.70608**	0.01
Anxiety yesterday	0.17	**0.6055**	0.07
Happiness in general	0.05	**0.89944**	0.03
Anxiety in general	-0.07	**0.97872**	0.03
GAD-7	-1.59	**0.0115**	0.30
PSS-10	-0.55	**0.44608**	0.14
PHQ-8	-0.65	**0.16876**	0.12
WHO-5	0.43	**0.71482**	0.09

Table A5.9: Between-sample difference between onboarding and exit questionnaire for well-being measures in study 3 (treatment effect).

Additional results – Effect of completing more EMA/DRM on treatment effect

A. **Study 1 - Anxiety yesterday**

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Model	coef	std err	P-value	N	F-statistic	Adj. R²
DRM counts	-0.0084	0.002	0.000	271	14.05	0.046
EMA counts	-0.0084	0.002	0.000	271	7.94	0.049

Table A5.10: Summary of regression models using (1) the number of DRM questionnaires answered and (2) the number of EMA questionnaires answered over the course of the study on the difference in anxiety yesterday between onboarding and exit questionnaire in study 1.

B. Study 1 - Anxiety in general

Model	coef	std err	P-value	N	F-statistic	Adj. R²
DRM counts	-0.0056	0.002	0.004	272	8.56	0.027
EMA counts	-0.0045	0.002	0.005	272	7.88	0.025

Table A5.11: Summary of regression models using (1) the number of DRM questionnaires answered and (2) the number of EMA questionnaires answered over the course of the study on the difference in anxiety in general between onboarding and exit questionnaire in study 1.

C. Study 2 - Anxiety in general

Model	coef	std err	P-value	N	F-statistic	Adj. R²
DRM counts	-0.0117	0.003	0.000	284	18.99	0.060
EMA counts	-0.0077	0.002	0.001	284	11.68	0.036

Table A5.12: Summary of regression models using (1) the number of DRM questionnaires answered and (2) the number of EMA questionnaires answered over the course of the study on the difference in anxiety in general between onboarding and exit questionnaire in study 2.

D. Study 3 – GAD-7

Model	coef	std err	P-value	N	F-statistic	Adj. R²
DRM counts	-0.1523	0.036	0.000	82	18.00	0.172

Table A5.13: Summary of regression models using (1) the number of DRM questionnaires answered and (2) the number of EMA questionnaires answered over the course of the study on the difference in GAD-7 between onboarding and exit questionnaire in study 3.

A6. Reflections app notes and screenshots

Additional notes on study design

The experience sampling data used in this thesis are part of a large-scale, experience sampling Randomised Controlled Trial (RCT) conducted at the LSE in partnership with Koa

Health. The majority of the study was based on the design of a previous experience sampling RCT that was conducted between the UK, Spain and Latin America (see chapter 6, study 1).

The RCT was composed of two arms: one "sham" control group, which received experience sampling questionnaires that asked them random questions rather than about their thoughts or well-being, and one treatment group, which received regular experience sampling questionnaires. Since chapters 3 to 5 of this thesis required experience sampling data about thoughts and well-being, only data from the treatment group were considered for these studies, and the data were treated as regular experience sampling data. Chapter 6 uses the data of the RCT part of the study.

The start of this PhD project coincided with the final stages of the study design. As such, there was little room for adding questions to the ones outlined above (including onboarding, well-being, thought and context questions). Nonetheless, the full questionnaire was reviewed by myself and all other researchers involved before the finalisation of the app. As a result, the activity question was changed.

In an earlier version of the study, people were asked to fill in the following statement when reporting their activity: *'In the past few hours, I was:'*. This was problematic, as it might cause people to reflect not just on the moment of notification, but on things that they were no longer doing. Since the prompt to report their thoughts was associated to this question, it was critical to make sure that people only reported what they were doing at the moment of the notification. As such, the activities question was changed to *'What were you doing just now?'*, such that subsequent company (*'I was with:'*) and thought prompts (*'I was thinking about:'*) were clearly referring to the moment of notification as well.

In addition, a mood question was added at the end of the questionnaire, to gage whether participants were content, excited, bored, anxious, angry, productive, sad, tired or relaxed, using emoticons to illustrate the emotion. However, since the answer to that question only provided a binary assessment of mood, we do not include it in the analysis of subsequent chapters.
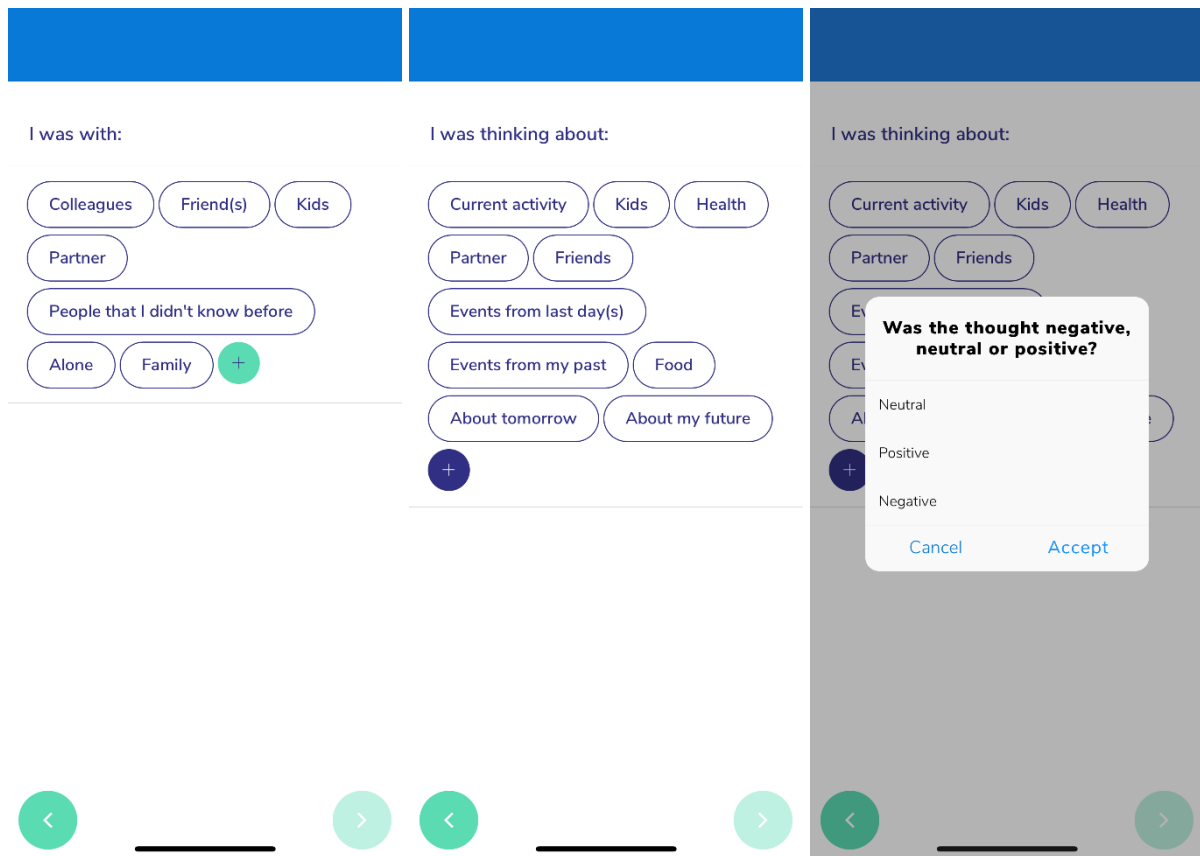
Screenshots

Below are relevant screenshots of the Reflections app, in order of appearance in the app.
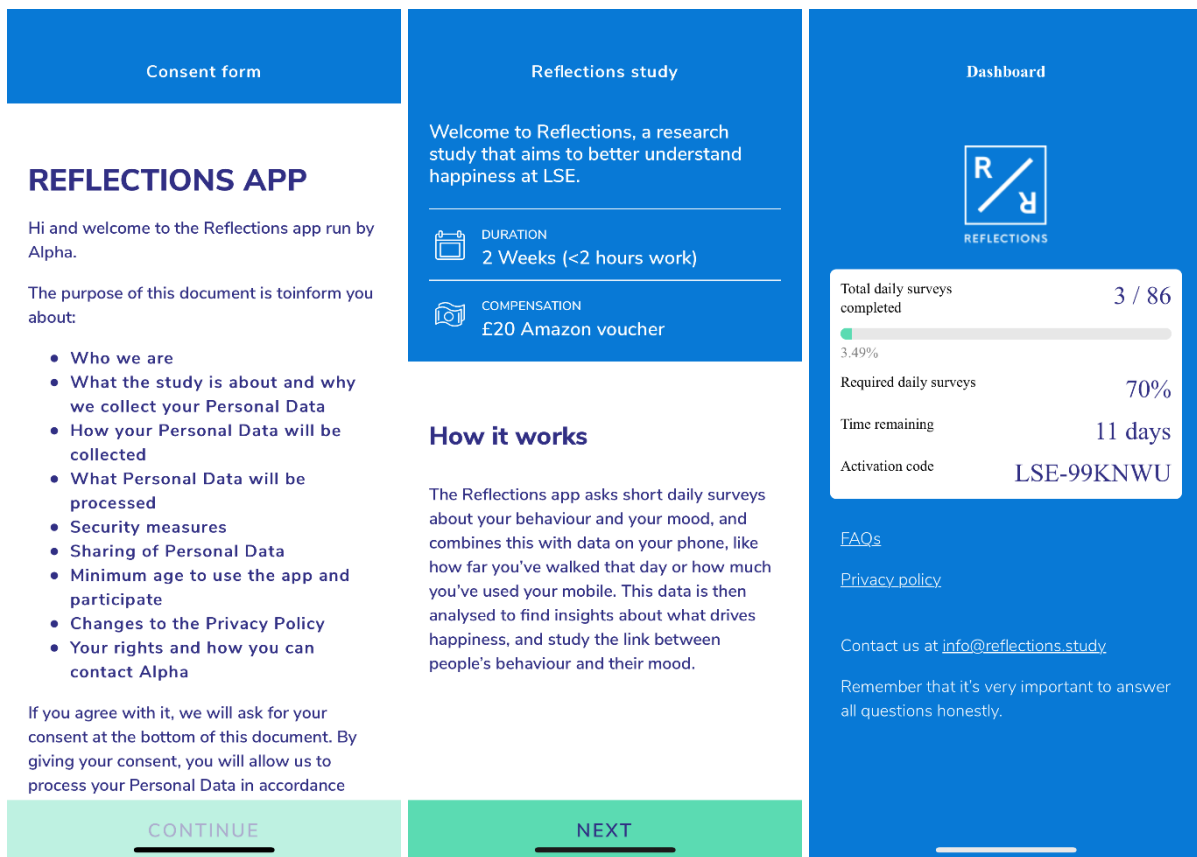
Screenshots 1-3: Consent form, study description and home page of the Reflections app.
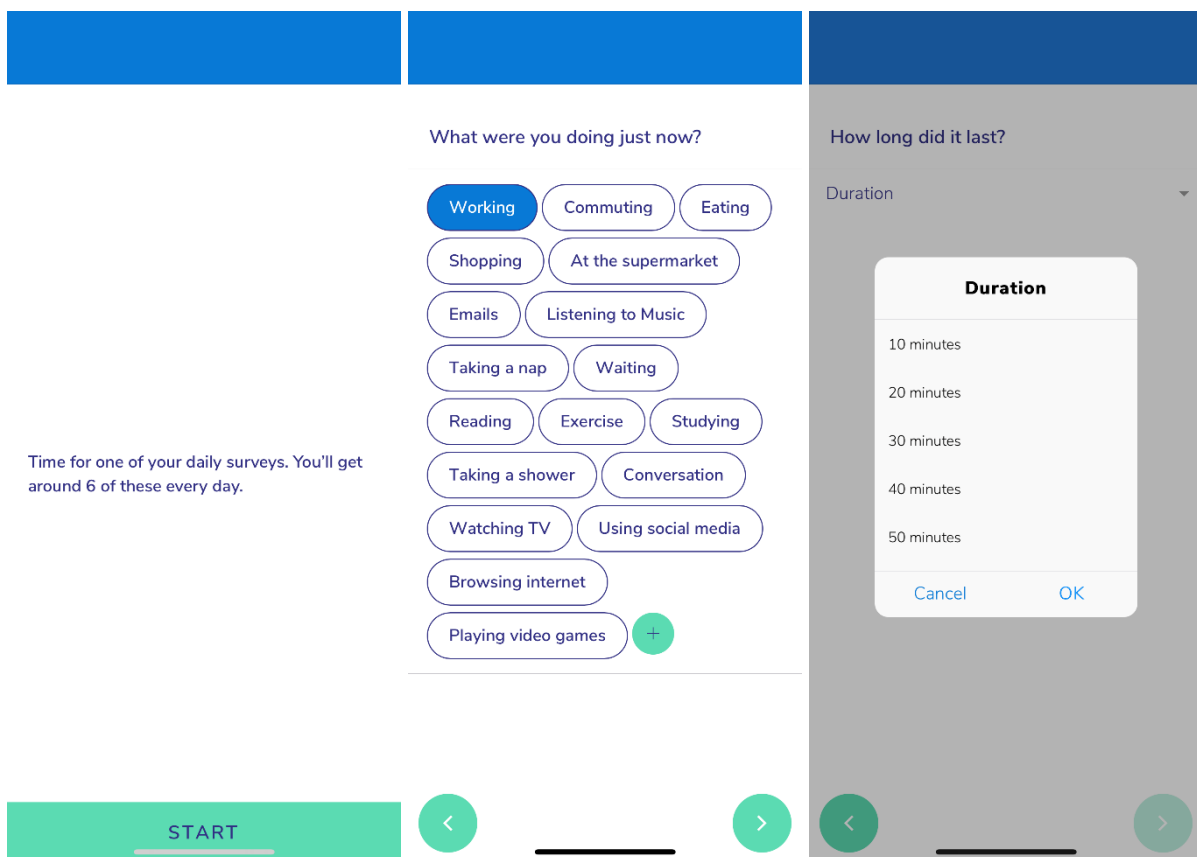
Screenshots 4-5: Opening screen for EMA notification, with activity and duration questions. The duration question was asked once people had selected all relevant activities.

Screenshots 7-9: Company and thoughts questions. For every selected thought, the valence of the thought was asked upon selecting the thought.

Where are you?

Home · Work · University

Library · Sport facility

Public transport (train, bus...)

Restaurant · Bar/Club · Cinema

Supermarket · Street/Outdoors

At my parents' house

At my friend's house

Holidays, away from my home city · +

How happy did you feel? (0 - Not at all, 10 - Completely)

0
1
2
3
4
5
6
7
8
9
10

Screenshots 10-11: Location question and happiness question. The worthwhileness question was presented in the same format as the happiness question, immediately following the happiness question.

How do you feel at the moment?
(Choose the one that describes your
current state best)

🙂 Content

😀 Excited

😐 Bored

😩 Anxious

😠 Angry

🤓 Productive

😢 Sad

😴 Tired

😌 Relaxed

Thanks!

SUBMIT

Screenshots 12-13: Additional mood question and exit screen.