



How Does Terrorism Affect Individuals' Wellbeing?

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Alex Bryson¹ and George MacKerron²

Abstract

This paper is the first to exploit high-frequency data to measure the impact of terrorist-related incidents (TRIs) on individuals' momentary happiness and anxiety. We show the impact of TRIs varies with the nature of the incident, the individual's physical proximity to it, and the time that has elapsed since the incident. TRIs have a substantial effect on individuals' momentary happiness and anxiety levels, but the effect is short-lived and is largely confined to incidents that lead to the death of victims and incidents within a twenty kilometre radius.

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I. Introduction

When assessing the impact of armed conflict, economists have focussed on its links to economic outcomes such as growth, investment, and trade (see Frey et al., 2007 for a review). Nevertheless, there is a recognition that the welfare costs of armed conflict extend beyond the direct economic effects to the psychic and emotional costs it inflicts on individuals. These costs can have their own deleterious economic effects. For example, fear of suicide bombings targeting public buses in Israel resulted in lower bus ticket sales (Becker and Rubinstein, 2011), use of air transportation in the United States fell by 15 percentage points following 9/11, and tourism in Israel fell by around two-thirds during the “Al-Aqsa” intifada (Becker and Rubinstein, 2011, Figures 1 and 2). Some have sought to capture the utility losses of people affected by conflict using subjective wellbeing (SWB) measures. Reflecting on the small literature in this area Frey et al. (2007: p.1) speculate that studies “in which individual utility is approximated by self-reported subjective wellbeing suggest that people’s utility losses may far exceed the purely economic consequences” (op. cit.: p.1). The statement is a bold one for three reasons: the number of such studies undertaken to date is small; findings do not all point in the same direction; and analyses are largely based on life satisfaction, which captures the reflexive component of SWB and may not be ideal for identifying welfare losses due to armed conflict.

We contribute to the literature by examining the effects of terrorist-related incidents (TRIs) on the feelings expressed at a moment in time.³ We do so by linking two datasets. The first records the exact time and place that TRIs occur. These incidents include killings, bombings, shootings, incendiary explosions, and armament finds. The second records individuals' happiness and anxiety levels as indicated by the scores they give in response to a random ding from their smartphone. These feelings relate to what has been termed "experienced utility" which is akin to "a continuous hedonic flow of pleasure or pain" (Kahneman and Krueger, 2006: p.4). The phone records the individual's exact location and the time so that we are able to locate where individuals were at the time of incidents. Participants respond, on average, twice a day, so we have high frequency data that permits inferences to be made about the causal sequencing of events occurring and individuals' wellbeing responses.

Our setting is Northern Ireland, a place that has been subject to a prolonged period of armed conflict dating back to the 1960s. At the height of the violence in 1972, 476 people died as a result of political violence. This is the setting for Frey et al. (2009) who identify a very high cost of terrorism by calculating the hypothetical willingness to pay for a reduction in the number of terrorist-related fatalities (see Section Two). Their analysis largely predates the 1998 Good Friday Peace Agreement, a framework agreement between the main parties to

³ We refer to these incidents as Terrorist-Related Incidents (TRIs), for convenience. In our setting the perpetrators of these acts are politically inspired. To some they will appear as terrorists, to others they will be freedom fighters. Either way, the events such as bombings and shootings recorded in our data are acts of

the conflict which led to a partial political solution to the conflict. Our wellbeing data begin in August 2010, more than 12 years after the Agreement. Besley and Mueller's (2012) study of house prices in Northern Ireland indicates there was a peace dividend arising from the Agreement. Nevertheless, although the Agreement led to a very substantial reduction in killings, bombings and shootings, these incidents still occur on a daily basis in Northern Ireland, as we show.

We find TRIs have a substantial effect on individuals' momentary happiness and anxiety levels, but the effect is short-lived and is largely confined to incidents that lead to the death of victims and incidents within a twenty kilometre radius.

The structure of the paper is as follows. Section II reviews the literature on TRIs and citizens' wellbeing, and presents hypotheses. Section III introduces our data. Section IV explains our identification strategy. Section V presents results and Section VI concludes.

II. The Effects of Armed Conflict on Subjective Wellbeing: Review and Hypotheses

A new literature seeks to identify the disutility of armed conflict by estimating the effects of terrorism on individuals' subjective wellbeing. Many of these studies

violence to attain political goals, often through the impact they have both on their immediate victims and their psychological effect on the wider population.

use life satisfaction to proxy utility. In one of the first studies of its type, Frey et al. (2009) estimated individuals' hypothetical willingness to pay for a discrete reduction in terrorism. They estimate life satisfaction equations based on pooled cross-sectional individual-level data covering Northern Ireland, the rest of the UK, the Republic of Ireland and France. The intensity of terrorism was proxied with the number of terrorist fatalities in a particular region and time. Using the estimated coefficients for terrorism and income they estimated a resident of Northern Ireland on average household income would be willing to pay between 26% and 37% of his/her income for a reduction in terrorist activity to the level that prevails in more peaceful parts of the country. Reflecting on their earlier results (Frey et al., 2004), which had estimated a willingness to pay of around 41%, the authors state: "This estimate is surprisingly high. However, it might to some extent reflect the ferocity of the conflict. After all Northern Ireland was on the brink of all-out civil war [over the period they study, 1975-1998]" (Frey et al., 2007: p.17).

The research by Frey and colleagues suggests TRIs have a very substantial impact on individuals' subjective wellbeing as captured by the way they reflect on their life satisfaction. And yet, Romanov et al. (2012) are unable to replicate this result for Israel. Estimating individual-level life satisfaction equations augmented with daily data on terrorist fatalities in Israel during the second *Intifada* in 2002–2004 they find no same-day effect on the life satisfaction of Jewish Israelis and no delayed effect. However, they do find the number of civilian fatalities in the

respondent's own city is negatively correlated with Arab Israelis' life satisfaction. They also report a sensitivity test using happiness as the dependent variable. The question asks: "In the last 30 days how often did you feel happy?". It is therefore capturing reflexive wellbeing rather than momentary wellbeing, though measured over 30 days rather than "life". Again, they find no link between Jewish Israeli wellbeing and the number of terrorist-related fatalities.

We contribute to the literature using unique individual high-frequency panel data to identify the effects of a variety of terrorist-related incidents (killings, bombings, shootings, incendiaries, finds) on two dimensions of individuals' momentary wellbeing, namely happiness and anxiety. We exploit precise information on the timing and location of events and individuals' responses to establish how these effects vary with the nature of the incident, the individual's distance from the incident, elapsed time since the incident, and the actual timing of the incident. With these data we are able to test the following hypotheses.

Hypothesis 1 (H1): TRIs reduce individuals' momentary wellbeing

One might anticipate that TRIs *have to* result in a lowering of individuals' momentary wellbeing. And yet Romanov et al. (2012) found terrorist-related fatalities in Israel were not associated with Jewish Israelis' life satisfaction, nor their 30-day retrospective happiness. Data limitations may have made it difficult for the analysts to detect any effect. For instance, they only have repeat cross-sectional data so they are unable to track the impact of a TRI on change in

wellbeing *within* individuals. Alternatively, their result may be correct. The authors conjecture that public policy and, in particular, Israel's counterterrorism strategy, may account for the absence of what they term a "demoralising" effect on the Jewish population. They also suggest that citizens may become resilient, adjusting to difficult circumstances, partly through adapting their behaviours to limit their exposure to TRIs. This is in the spirit of Becker and Rubinstein's (2011) model under which citizens incur costs, via modest adaptations to their daily lives, in order to mitigate the worst aspects of terrorism. If "full adaptation" is possible, then perhaps we may find no effect of TRIs on momentary happiness. Yet Becker and Rubinstein's (2011) paper is not consistent with full adaptation. Instead, they pick up an effect of TRIs in the form of a reduction in the sale of bus tickets among marginal users. Frey et al. (2009) find terrorism has a sizeable negative coefficient in life satisfaction equations in Northern Ireland, which also suggests citizens do not fully adapt to TRIs.

Hypothesis 2 (H2): The size of any TRI effects will vary with the type of incident

Most studies on the impact of armed conflict rely on fairly crude indicators of violence or terrorism. Often only the number of deaths in a period is available. Others use proximity in time and space to a single event, such as 9/11. As noted in Section III and Table 1 below, we have information on seven different types of TRIs. We anticipate the wellbeing effects of deaths and, perhaps, bombings, will be greater than for other events due to the magnitude of the effect on human life. At the other end of the spectrum it is unclear what impact, if any, finds will have

on individuals' wellbeing. On the one hand, finds may generate unhappiness and anxiety if viewed as an indication of armed groups' continued desire to cause harm. On the other hand, finds by the Police Service for Northern Ireland (PSNI) mean those armaments are no longer available to terrorist groups, making communities safer than they might otherwise have been. It is also possible that incidents such as finds will remain unreported by the media, so citizens will remain unaware of them.⁴

Hypothesis 3 (H3): The size of TRI effects will vary with physical proximity to the event

We anticipate that any effects of TRIs on individuals' momentary wellbeing will be greater the closer an individual is to the event. The full enormity of an event may only be apparent to eye-witnesses.

In their national survey of psychological stress levels in the United States conducted in the few months after the 11 September 2001 terrorist attacks Schuster et al. (2001) found no abnormal stress levels, other than in the New York City metropolitan area where there were symptoms of post-traumatic stress disorder (PTSD). In their national survey, Silver et al. (2002) found the likelihood of people suffering PTSD was greater among those living closer to New York

⁴ Media coverage of tragedy can generate stress and anxiety (Schlenger et al., 2002; Slone, 2000). Becker and Rubinstein (2011) show even dramatic events like suicide attacks on buses in Israel have almost no effect on individuals' propensity to purchase bus tickets if the event did not attract media attention.

City.⁵ However, 9/11 was a huge national trauma, something that Northern Ireland may have experienced with the Omagh bombing in 1998 which killed 29 people.⁶ The Boston Marathon bombing which killed three people in 2012 is, perhaps less atypical of events that might occur in Northern Ireland. It resulted in a substantial reduction in positive affect which was larger for those in nearby States (Clark et al., 2017).⁷

An alternative hypothesis is that a TRI may affect everybody in a small country like Northern Ireland, regardless of where it occurs. For instance, an event such as a bombing might be viewed as an attack on the people of Northern Ireland as a whole, and thus be felt as much by people far from the event as it is by people in close proximity to it. Alternatively, TRIs may affect the momentary wellbeing of people far from an event and those who actually have a low risk of being directly caught up in a TRI, either because the fear of terrorism enters their utility function directly (as Becker and Rubinstein (2011) suggest) or because people exaggerate the chance of a TRI affecting them directly. Any effects of TRIs on individuals' wellbeing may be large even when far from an event if people attach greater weight to losses than to gains in their emotional responses, as predicted by prospect theory (Kahneman and Tversky, 1979). Metcalfe et al. (2011) find the 9/11 attack in the United States raised mental distress among citizens in the

⁵ For a review of the literature on the psychological state of general populations following TRIs and direct effects on victims see Whalley and Brewin (2007).

⁶ Using self-completion questionnaires distributed at schools, Duffy et al. (2015) find adolescents aged between 14 and 18 exposed to the bombing exhibited high rates of PTSD.

⁷ Clark et al. (2017) use regression discontinuity and event analyses based on data collected via the Day Reconstruction Method to identify the effects of the bomb on experienced wellbeing.

United Kingdom, an effect they attribute to the fear and uncertainty generated by the perception of a heightened threat of a terrorist attack in the UK (op. cit.: F96).

Whatever the mechanism by which TRIs may affect a large population⁸, the idea that a TRI may affect all in Northern Ireland is akin to what Besley and Mueller (2012: p.827) referred to as the “single index” hypothesis in their study of TRIs and house prices. They find region-specific effects are robust to accommodating a single index (op. cit., pp.826–828). If all in Northern Ireland are affected similarly by TRIs this would be discernible relative to others in Britain. To distinguish between the effects of TRIs and a temporal shift in momentary wellbeing that is contemporaneous with a TRI we introduce the mean residual wellbeing for the rest of Britain as a control variable, such that we are able to detect divergence between British and Northern Irish momentary wellbeing due to TRI. (See Section III for discussion of the British measure of wellbeing).

Hypothesis 4: The size of any TRI effect will diminish with time

There is an established psychological literature which suggests individuals have subjective wellbeing “set points” to which they are anchored over the long run. When faced with unfortunate events they deviate from these set points, only to return to them not long afterwards (see, for example, Cummins et al., 2014).

⁸ For a discussion of possible mechanisms which compares Kahneman and Tversky’s perspective with that of Becker and Rubenstein, see Krueger (2007: pp.127–129).

Some of the evidence surrounding the psychological impact of TRIs is consistent with this proposition. A survey conducted in the United States three to five days after the terrorist attacks on 11 September 2001 found Americans across the country exhibiting high levels of stress (Schuster et al., 2001), but a survey conducted one to two months after the attacks found overall psychological distress levels were within normal ranges (Schlenger et al., 2002). Similarly, Stecklov and Goldstein (2004) identify an increase in fatal car accidents in Israel after terrorist attacks, accompanied by a reduction in non-fatal accidents. They interpret this effect, which dissipates after a few days, as consistent with drivers being temporarily distracted by TRIs. Other studies suggest adaptation occurs after some months. For example, Silver et al. (2002) recorded very high levels of stress and anxiety in the US population outside New York City in the few months after 9/11, which had fallen to near-normal levels after six months. Metcalfe et al. (2011) find the heightened mental distress of UK citizens linked to the 9/11 attacks in the United States dissipated after four months.

The study most like ours in its approach is Krueger's (2007: pp.122–124) analysis of an experience sampling study of individuals in Wisconsin. The study took frequent readings throughout the day on how individuals were feeling, asking them "How sad do you feel?" and "How enthusiastic do you feel?". Krueger finds a large jump in reported sadness on 9/11, but this returns to its

baseline level within 4 days. However, the impact on enthusiasm lasts longer.⁹ Similarly, Clark et al. (2017) find the effects of the Boston Marathon bomb on experienced wellbeing do not persist beyond a week.

Hypothesis 5: TRIs are liable to affect feelings of anxiety more than they do momentary unhappiness

Psychologists distinguish several dimensions of wellbeing. One is the dimension of affect, which can be positive, as in the case of happiness, or negative (unhappiness). A second is anxiety-contentment. Anxiety combines unhappiness and high levels of emotional arousal, whereas contentment combines happiness with low levels of emotional arousal (Russell, 1980, 2003). It is plausible that TRIs may have a greater bearing on anxiety than they do on (un)happiness. This is because anxiety is closely linked to stress, which is what Schuster et al. (2001) were detecting in their study post-9/11. Clark et al. (2017) is one of the few studies to examine the effects of a terrorist event on alternative wellbeing measures. They find the significant effects of the Boston Marathon bomb on positive and negative affect in the first week after the bombing were opposite in sign but similar in size.¹⁰

⁹ It is possible that citizens may only get to hear about smaller TRIs through newspapers and other printed media, in which case one might anticipate some delay between the event and any effects on citizens' wellbeing.

¹⁰ The construct a positive affect indicator on feelings of happiness and meaningfulness and a negative affect indicator on feeling sad, tired, stressed and pained.

III. Data

We match two datasets, one on TRIs and one on momentary wellbeing. We discuss each in turn.

Police Service for Northern Ireland (PSNI) data on security-related incidents

The data from the PSNI record the exact time and postcode location of security-related incidents recorded by the police in Northern Ireland from 1999 onwards. These incidents — which we term TRIs — include security-related deaths, paramilitary-style shootings, non-paramilitary-style shootings, paramilitary-style assaults, bombings, ammunition and explosive finds and incendiaries. All these data are sourced from the PSNI's security-related database which is held by the PSNI's Statistics Branch.¹¹

Mappiness¹²

Mappiness permits individuals to record their wellbeing via a smartphone. The data contain more than a million observations on tens of thousands of individuals in the UK, collected since August 2010. Individuals who have downloaded the app receive randomly timed 'dings' on their phone asking them to complete a very short survey.¹³ The survey asks individuals to rate themselves on three dimensions of momentary wellbeing, stating how happy, how relaxed, and how

¹¹ The data are held securely by NIESR under an information sharing agreement with the PSNI.

¹² <http://www.mappiness.org.uk/>

awake they feel. Each score is elicited by means of a continuous slider (a form of visual analogue scale — see Couper et al., 2006). The ends of each scale are labelled ‘Not at all’ and ‘Extremely’, and an individual positions him or herself on the scale by drawing a fingertip across the screen. Having completed this phase, the individual is asked whether they are alone and, if not, whom they are with. They are then asked whether they are indoors, outdoors, or in a vehicle, and whether they are at home, at work, or elsewhere. Finally, they are asked what they were doing ‘just now’. The respondent chooses all that apply out of 40 response options. The complete survey is reproduced in Appendix A.

Individuals complete a short survey about their personal, work and household characteristics when registering for *Mappiness*. Because users report when they are at home, we can identify home location for any user who responds at least once from there, and we use this to establish how far TRIs are from the respondent’s home community.¹⁴ *Mappiness* also records the time elapsed between the random ‘ding’ and response, thus allowing us to distinguish between immediate, ‘random’ responses and delayed responses.

¹³ Individuals can choose to be signalled between one and five times a day. Most stick to the default option, which is twice a day. They also specify the hours of the day during which they are likely to be asleep and do not wish to be disturbed.

¹⁴ In Bryson and MacKerron (2017) we compare the sorts of individuals providing *Mappiness* data to the population at large. We show that they are unrepresentative in some respects, e.g. younger and more wealthy, which means that the correlations we report below cannot be extrapolated to the population at large. However, although the magnitude of effects may differ in the population at large, it seems unlikely that the results presented below would be overturned if the survey were completed by a group of individuals who were more representative of the population as a whole.

Together with the responses to the survey, the *Mappiness* app transmits the satellite positioning (GPS) location of the individual and the precise time at which the survey was completed. When linked to the PSNI data, these allow us to establish precisely where the individual was in relation to a TRI, and the precise timing of a response relative to when an incident occurred.

[INSERT TABLE 1]

The matched PSNI-Mappiness data contain 30,015 Mappiness responses from 445 individuals (67 responses per person) over the period August 2010 to March 2013. Over this period, PSNI recorded 993 TRIs, over half (55.9%) of which were finds. Together these 993 incidents constitute 10.6% of all the TRIs recorded in the PSNI data base since 1999 (Table 1). Between January 1999 and end March 2013 the PSNI data record 93 incidents leading to death. Only 3 of these happened during the period for which we have Mappiness data. However, our PSNI-Mappiness data contain 295 Mappiness responses in the seven day periods after those deaths, including 87 responses within 5 kilometres of the death and 38 responses within 24 hours of a death (Appendix Table A1). In contrast, there were 145 bombings between August 2010 and March 2013. Mappiness recorded 25,365 responses in the week subsequent to a bombing including 2,147 responses within 5 kilometres of the bombing and 4,413 responses within 24 hours of a bombing.

IV. Estimation strategy

We explore the links between individuals' wellbeing (happiness and anxiety) measured momentarily at random points in time and their exposure to TRIs. Both distributions of momentary wellbeing are skewed (Figure 1). There is also a notable spike at the top of the scale, suggesting right truncation with individuals scoring as high as they possibly can. The estimates presented in Section V are not sensitive to the use of interval regression techniques to tackle this issue.¹⁵

[INSERT FIGURE 1]

Individuals provide a *Mappiness* response when randomly requested to do so during the course of the day: the random 'ding' elicits responses which are random with respect to where the respondent is, what they are doing and how they are feeling. However, individuals do not always respond, and may respond after some delay, especially if affected by an unfortunate event such as a TRI. We restrict our analyses to responses given within one hour of the signal being sent. Under this criterion, approximately half of all signals result in a valid response. We find our results are not sensitive to varying this period.

As a further sensitivity test, we can exclude all responses from respondents with a highly incomplete response record, in case the choice to respond is correlated with affective state and this biases our coefficient estimates. Again, this has little

¹⁵ These results are available from the authors on request.

impact on our results. The *Mappiness* survey is designed to be fast and convenient, and over half of responses are completed in under 30 seconds. So any self-selection may be no more serious than for more traditional panel surveys, in which individuals are expected to commit a much larger amount of time to answering survey items, albeit in fewer and less frequent instalments.

Because the average individual responds about 60 times, we are able to account for unobservable fixed differences across individuals. We present correlations between changes in individual wellbeing and exposure to TRIs within person over time. Since TRIs are relatively random events one might think of them as random shocks to people's wellbeing, allowing us to make causal inferences about the relationship. However, individuals' exposure to TRIs is not totally random. First, terrorists may seek out times and places to maximise the impact of their activities. Second, individuals may locate themselves far from (near) places where the perceived risks are high (low) according to the degree to which they are risk-averse. To the extent that non-random exposure to TRI is associated with fixed personal traits these are accounted for by the person fixed effects.¹⁶ Person fixed effects models also avoid complications in making inter-personal comparisons which are inherently difficult to make when individuals' reference points against which they score their wellbeing can differ markedly.

¹⁶ It is possible, for example, that individuals with a greater tolerance for stress may be less concerned to avoid places which have a greater propensity to attract TRIs. Within-person estimates sidestep the downward bias in TRI effects that this sort of selection into TRI situations might induce.

Our period of observation begins in August 2010 and ends in March 2013. The models we present are of the following type:

$$h_{it} = \alpha_i + \beta_a t_{it-24} + \beta_b t_{it-2472} + \beta_c t_{it-727d} + \beta_r r_{it} + \beta_x X_{it} + \varepsilon_{it}$$

where h is happiness (or anxiety) of individual i at time t , t_{it-24} is a TRI occurring within a certain distance from the respondent in the last 24 hours; $t_{it-2472}$ is a TRI of the same type occurring within a certain distance from the respondent 24 to 72 hours ago; and $t_{it-727d}$ is a TRI of the same type occurring within a certain distance from the respondent in the period 72 hours to 7 days before the respondent's *Mappiness* response. These time dummies are constructed to be mutually exclusive, with TRIs that occurred over 7 days ago ignored. The β are parameters to be estimated; α_i is the person fixed effect; and ε_{it} is the error term.

To distinguish between the effects of TRI and a temporal shift in momentary wellbeing that is contemporaneous with a TRI we introduce the mean residual wellbeing for the rest of Britain (r_{it}) as a control variable, such that we are able to detect divergence between British and Northern Irish momentary wellbeing due to TRIs. This residual is derived from a happiness equation run on data for respondents in Great Britain on the same day as the respondent in Northern Ireland responds. The Great Britain happiness model conditions on month, day of the week, time of day, and the number of responses given by the respondent to

date. We derive a residual from an anxiety equation in precisely the same way and condition on it in the anxiety equations we present below.

Other right-hand side control variables in the \mathbf{x} vector include time indicators (month, day of week, time of day) and the number of responses an individual has given previously.

Models are run separately for each of seven types of TRI — namely deaths, bombings, incendiaries, paramilitary-style assaults, paramilitary shootings, non-paramilitary shootings, and finds — and for four sets of distances from the respondent corresponding to TRIs occurring up to 5 kilometres away, up to 10 kilometres away, up to 20 kilometres away and those occurring anywhere throughout Northern Ireland. This totals 84 happiness models and 84 anxiety models. Together these models allow us to test Hypothesis 1 (whether TRIs are associated with lower wellbeing; Hypothesis 2 (their impact varies by type of incident); Hypothesis 3 (their impact varies with physical proximity to the incident); Hypothesis 4 (their impact diminishes with time elapsed since the incident); and Hypothesis 5 (their impact on anxiety is greater than their impact on happiness).

The history of the conflict in Northern Ireland indicates that some locations are much more prone to TRIs than others. These geographical patterns have persisted over many years (Besley and Mueller, 2012). This is apparent from the

four maps showing the incidence of all TRIs (excluding finds) since PSNI began collating comprehensive data on TRIs in 1999 and the month before *Mappiness* data were available (Figure 2). The darkest shading shows the local authorities with over 250 TRIs (1,793 in the case of Belfast and 260 in Derry), while Omagh experienced only 4 incidents.

[INSERT FIGURES 2 AND 3]

Figure 3 presents the same information for the period 16 August 2010 to 31 March 2013 for which we have *Mappiness* data. The 438 non-find incidents were again heavily concentrated in Belfast (163) and Derry (62). Moyle had none.

[INSERT FIGURES 4 AND 5]

Figures 4 and 5 show the location of the 93 deaths that occurred over the period 1st January 1999 to 31st March 2013. Thirty-three happened in Belfast, nine in Newtownabbey, and seven in Derry. The three that took place between August 2010 and March 2013 were in Belfast, Newtownabbey and Craigavon.

We captured expectations based on experience of these historical patterns of conflict by adding local authority fixed effects to our model. These within-area estimates account for otherwise unobservable fixed differences across locales, such as the history of conflict in a local area, which might otherwise bias our

estimates of the direct links between TRIs and wellbeing. However, their inclusion made little difference to our results, so we do not report them here.¹⁷

Standard errors are clustered at the person level to account for non-independent repeat observations and a robust estimator is deployed to account for heteroskedasticity. The response variables are scaled from 0 – 100, so coefficients can be interpreted as percentage changes.

To interpret the size of any wellbeing responses to TRIs we compare the size of the coefficients with those associated with other events and activities, such as being sick in bed or being unemployed. Frey et al. (2007) estimate the effects of terrorism on life satisfaction are roughly equivalent to the size of unemployment effects which, as Krueger (2007: p.125) notes is “a significant effect indeed”.

V. Results

Table 1 presents estimates of the correlation between momentary happiness and TRIs using the baseline person fixed effects specification described in Section IV. Variables in the models perform as expected. For instance, happiness rises through the course of the day and varies significantly across days of the week. Residual happiness of respondents in Great Britain is strongly positively correlated with the happiness of respondents in Northern Ireland. By way of

¹⁷ They are available from the authors on request.

illustration, the full models for TRIs resulting in death are presented in Appendix Table A2.

[INSERT TABLE 1]

The TRI effects are consistent with the propositions identified in our hypotheses. TRIs tend to be negatively correlated with momentary happiness, as anticipated in Hypothesis 1. However, the effects are largely confined to TRIs resulting in the death of victims. There are no significant correlations between recent TRIs and shootings or paramilitary-style assaults. There are a handful of statistically significant effects associated with incendiaries, bombings and fires, but one needs to be cautious in over-interpreting results when running so many models since, by chance, some coefficients will appear statistically significant. Results are therefore consistent with the contention in Hypothesis 2 that TRI effects vary according to the nature of the incident. The pattern of coefficients associated with TRIs leading to deaths also indicate that the size of TRI effects diminishes with physical distance from the TRI (Hypothesis 3) and with time elapsed since the event (Hypothesis 4).

The most consistent significant effects relate to TRIs leading to deaths that occurred between 24 and 72 hours ago. These TRI-related deaths result in a 12.6% decline in momentary happiness when they occur within 5 kilometres of the respondent, but this falls to around 8% when the event occurs up to 20

kilometres away, and halves to 4% and is barely statistically significant if one includes all TRIs leading to deaths occurring throughout Northern Ireland. The absence of significant effects in the first 24 hours could reflect the time it takes for people to hear about an incident.¹⁸ The absence of effects that occurred at least 3 days ago is reminiscent of the effects Krueger found in relation to 9/11.

[INSERT TABLE 2]

Table 2 presents identical estimates but this time for anxiety rather than happiness. The coefficients are reversed so that they capture the opposite of anxiety, namely contentment so as to parallel the results in Table 1. The models perform better than those for happiness and the effects of TRIs leading to deaths on anxiety is a little larger than it is for happiness, as anticipated in Hypothesis 5. It is clear that TRIs leading to deaths increase anxiety for up to 72 hours: the effects in the first 24 hours are large and statistically significant, but they rise a little in the following 48 hours. However, they disappear after 72 hours. The effects are also harder to discern when they occur more than 20 kilometres away. Similar, though weaker, effects are apparent for TRIs involving incendiary devices, and there are some much smaller effects for finds, but once again there is no correlation with assaults and shootings.

¹⁸ Focusing solely on TRIs that occur within a 2 kilometre radius reveals a large (21%) fall in momentary happiness within the first 24 hours, perhaps because when an incident occurs so close by one is not reliant on others to communicate what has happened.

To establish whether expectations linked to locality effects influence the size of TRI effects we introduced 27 dummies capturing the local authority in which the incident occurred. These dummies are jointly statistically significant but they only marginally reduce the size of TRI coefficients. For example, in the local authority fixed effects models exposure to a TRI leading to death that occurred within 5 kilometres and in the last 1 to 3 days results in a reduction of 12.4% in momentary happiness when incorporating the local authority effects, compared with 12.6% in the baseline equivalent model in Table 1. Thus the effects of TRIs leading to deaths are apparent within locality.

VI. Conclusions

This paper is the first to exploit high-frequency data to measure the impact of terrorist-related incidents (TRIs such as killings, bombings, shootings, incendiaries, assaults and finds) on individuals' momentary happiness and anxiety. We exploit precise information of the time and location of events and individuals to establish how these effects vary with the nature of the incident, the individual's distance from the incident, elapsed time since the incident, and the actual timing of the incident.

We show the impact of TRIs varies with the nature of the incident, the individual's physical proximity to it and the time that has lapsed since the incident. We find TRIs have a substantial effect on individuals' momentary happiness and slightly larger effects on anxiety levels, but the effects are short-lived and are largely

confined to incidents that lead to the death of victims and incidents within a twenty kilometre radius. These effects are apparent within localities as well as across localities, suggesting that expectations associated with histories of localised violence do not prepare individuals for the effects of TRIs.

Our results are reminiscent of some others in the sparse literature on this subject. Proximity to an event in time and space have a strong bearing on the effects TRIs have on individuals' wellbeing. The effects are more apparent in relation to anxiety than they are to happiness, as one might expect since TRIs are liable to induce stress. What is, perhaps, surprising is how quickly the effects appear to wear off — they are not apparent after 72 hours — and how extreme the events have to be in order to register with individuals. In our data, it is only events leading to deaths that have a consistent effect on momentary wellbeing and, even then, the event needs to have taken place within 20 kilometres of the individual. These findings are not unlike many of those appearing in the literature on 9/11 effects in the United States. They are unlike the findings of Metcalfe et al. (2011) who found effects of 9/11 on UK citizens' mental distress four months later: differences in the results across studies may relate to the measure of distress or anxiety used in the studies, the mechanism generating the negative impact on wellbeing, or the nature of the events themselves. However, based on this and other studies, it does appear surprising that Romanov et al. (2011) find no effect of TRIs on Israelis' wellbeing.

The effects we find are fairly sizeable, although they are no larger than the effects we identified in our earlier *Mappiness* study regarding the negative association between happiness and episodes of work (Bryson and MacKerron, 2017). It might be reasonable to ask: why aren't the effects more pronounced? Certainly, the fact that the effects do not persist for long is consistent with the literature indicating that individuals' wellbeing often adapts quite quickly to negative shocks.

It is possible that we have understated the size of the TRI effects on happiness and anxiety. For example, in the extreme, those likely to be most affected by TRIs may take steps to avoid being in the wrong place at the wrong time, and thus will be less likely to be exposed to TRIs. Thus, when we try to identify TRI effects by looking at exposure to them within individuals over time, we may simply have too little variance in exposure among those most likely to be affected. We might also underestimate TRI effects if those who are exposed to TRIs fail to respond to their *Mappiness* ding, as might conceivably be the case if badly affected by the event.

Although the effects we identify do not last very long, they may nevertheless have important consequences for those exposed to TRIs. Shany (2017) shows that terror attacks in Israel during the Second Intifada had a significant adverse impact on pupil exam performance. Although the effect was transitory, affecting pupil performance only in the five days prior to an examination, this had long-

lasting effects on human capital accumulation because TRIs prior to a matriculation examination reduced the probability of passing the exam, obtaining a matriculation certificate and the quality of any certificate earned.

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Table 1: Terrorist-Related Incidents, January 1999 – 31 March 2013

	Jan 1999 – 15 Aug 2010	16 Aug 2010 – 31 Mar 2013	Jan 1999 – 31 Mar 2013
Deaths	90	3	93
Bombings	1,156	145	1,301
Incendiaries	62	3	65
Paramilitary-style assaults	1,156	112	1,268
Paramilitary shootings	1,043	81	1,124
Other shootings	1,031	94	1,125
Finds	3,798	555	4,353
All	8,336	993	9,329
Note: postcode data for incendiaries is only available from 1 st May 2001			

Table 2: TRIs and Momentary Happiness

	Model 1			Model 2			Model 3			Model 4		
	5km 24h	5km 24h72h	5km 72h7d	10km 24h	10km 24h72h	10km 72h7d	20km 24h	20km 24h72h	20km 72h7d	anywh 24h	anywh 24h72h	anywh 72h7d
Finds	0.00	-0.58	-0.99 +	-0.16	-0.58	-1.42 **	-0.23	-0.69 *	-1.15 **	0.09	-0.15	-0.21
Bombings	0.42	0.84	-1.57 *	-0.88	-0.08	-1.29 *	0.19	0.03	0.02	0.06	0.14	0.14
Deaths	-6.26	-12.59 **	1.07	-5.20	-7.99 *	1.45	-4.51	-7.83 **	1.28	-3.24	-3.78 +	-1.48
Incendiaries	-8.86	-0.60	-5.90 +	-7.12	-8.20 +	-3.78 *	-7.16	-8.29 **	-2.50 +	-1.42	-0.54	1.37
Paramilitary-style assaults	0.15	-0.90	0.22	0.08	-1.15	-0.27	-0.06	-0.7	-0.56	-0.07	0.06	-0.07
Paramilitary Shootings	-0.60	-1.32	-0.89	-0.11	-0.76	-0.64	0.18	-0.31	-0.76	0.25	0.22	-0.04
Non-paramilitary Shootings	-1.22	-1.35	0.19	-0.33	-0.96	0.35	0.04	-0.39	0.64	0.41	-0.42	-0.09

Notes:

(1) Each cell contains the TRI coefficient for a recent TRI event.

(2) Statistical significance is denoted as follows + 10% * 5% ** 1%

(3) Types of TRI are entered separately into the models. For instance, the “Finds” models only contain finds. In total, 28 regression models are summarised.

(4) Model 1 identifies the effects of TRIs within 5km of the respondent. Model 2 identifies the effects of TRIs within 10km of the respondent, and so on.

Table 3: TRIs and Momentary Anxiety

	Model 1			Model 2			Model 3			Model 4		
	5km 24h	5km 24h72h	5km 72h7d	10km 24h	10km 24h72h	10km 72h7d	20km 24h	20km 24h72h	20km 72h7d	anywh 24h	anywh 24h72h	anywh 72h7d
Finds	-0.25	-0.65	-1.40 **	-0.29	-1.08 **	-1.64 ***	-0.45	-0.71 *	-1.40 ***	0.09	-0.11	-0.41
Bombings	0.60	0.44	-1.30 +	-1.17	-0.40	-1.45 *	0.13	-0.53	-0.09	0.26	0.17	0.32
Deaths	-9.83 **	-13.44 *	0.05	-9.64 **	-10.54 **	0.64	-7.85 **	-11.64 **	0.59	-5.19 +	-6.53 *	-0.38
Incendiaries	-7.55 ***	6.04 *	0.13	-4.68	-4.78 *	0.50	-7.83 *	-7.56 ***	-0.07	-1.10	-0.30	2.73
Paramilitary-style assaults	-1.27	-0.73	0.21	-0.96	-1.08	-0.19	-0.85	-1.08 *	-0.80 +	-0.34	-0.42	-0.51
Paramilitary Shootings	0.02	0.17	-0.87	0.30	-0.10	-0.57	0.39	-0.20	-0.45	0.27	0.34	-0.13
Non-paramilitary Shootings	-2.64 +	-0.54	-0.57	-0.63	-0.29	-0.03	0.18	0.19	0.24	0.14	0.16	0.26

Notes:

(1) Each cell contains the TRI coefficient for a recent TRI event.

(2) Statistical significance is denoted as follows + 10% * 5% ** 1%

(3) Types of TRI are entered separately into the models. For instance, "Finds" models only contain finds. In total, 28 regression models are summarised.

(4) Model 1 identifies the effects of TRIs within 5km of the respondent. Model 2 identifies the effects of TRIs within 10km of the respondent, and so on.

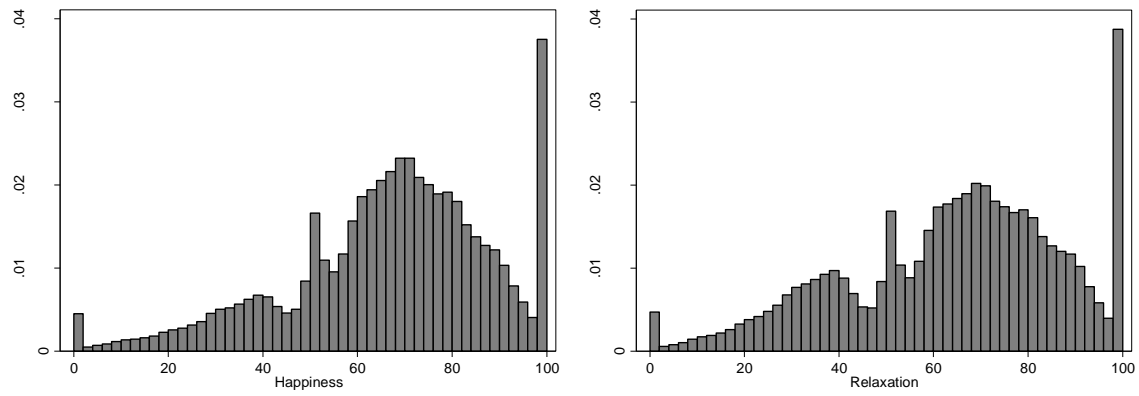


Figure 1. Distributions of 'happy' and 'relaxed' responses, full sample

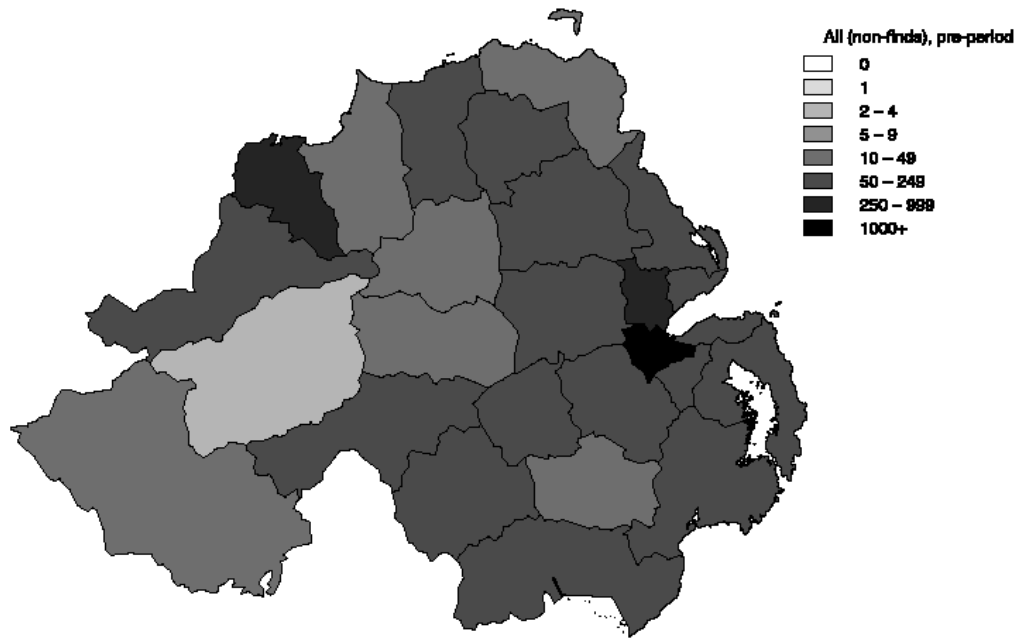


Figure 2: All Terrorist-Related Incidents (excl. finds), January 1999 – 15 August 2010

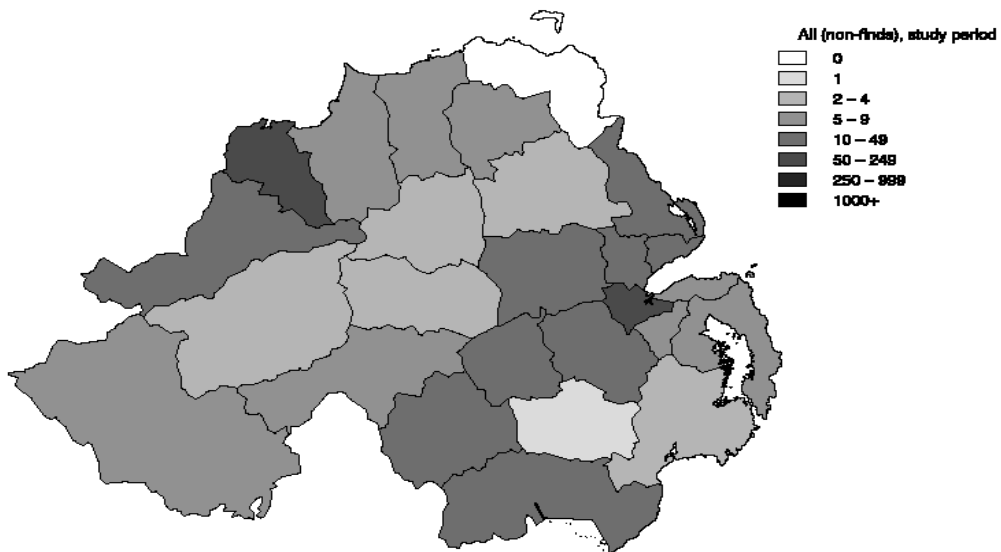


Figure 3: All Terrorist-Related Incidents (excl. finds), 16 August 2010 – 31 March 2013

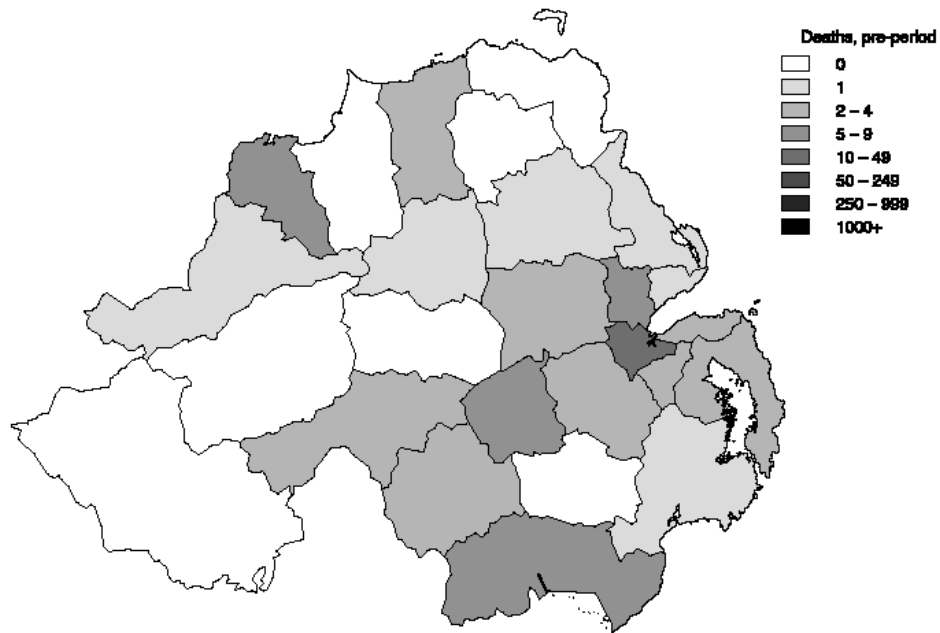


Figure 4: Deaths, January 1999 – 15 August 2010

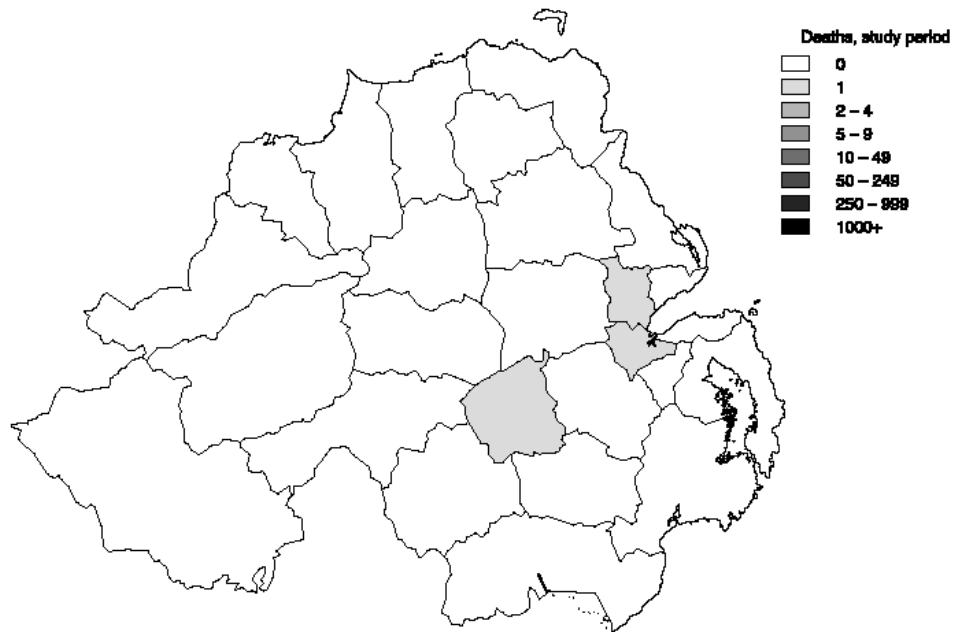
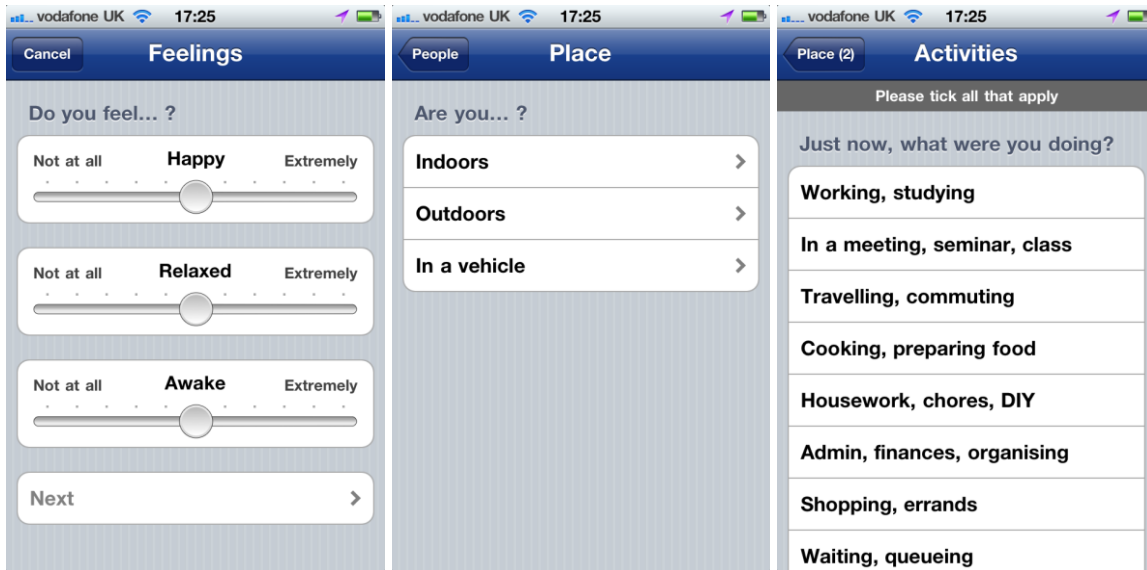


Figure 5: Deaths, 16 August 2010 – 31 March 2013

Appendix A: The survey instrument



If a signal has been received, the app launches directly into the questionnaire.

The questionnaire spans multiple screens, delineated below by horizontal rules. Tapping an option suffixed by '>' immediately advances to the next screen.

The first screen has a 'Cancel' button that discontinues the questionnaire, and each subsequent screen has a 'Back' button to return to the preceding screen.

THIS SCREEN IS ILLUSTRATED ABOVE

Feelings

Do you feel... ?

Happy (slider: Not at all ... Extremely)

Relaxed (slider: Not at all ... Extremely)

Awake (slider: Not at all ... Extremely)

Next >

People

Please tick all that apply

Are you... ?

Alone, or with strangers only >

Or are you with your... ?

Spouse, partner, girl/boyfriend

Children

Other family members

Colleagues, classmates

Clients, customers

Friends

Other people you know

Next >

THIS SCREEN IS ILLUSTRATED ABOVE

Place

Are you... ?

Indoors >

Outdoors >

In a vehicle >

Place (2)

And are you... ?

At home >

At work >

Elsewhere >

If you're working from home, please choose 'At home'

THIS SCREEN IS ILLUSTRATED ABOVE

THE ACTIVITIES LIST IS ADAPTED FROM THE AMERICAN TIME USE SURVEY ACTIVITY LEXICON 2009 (US BUREAU OF LABOR STATISTICS) AND THE UNITED KINGDOM 2000 TIME USE SURVEY (UK OFFICE FOR NATIONAL STATISTICS).

Activities

Please tick all that apply

Just now, what were you doing?

- Working, studying
- In a meeting, seminar, class
- Travelling, commuting
- Cooking, preparing food
- Housework, chores, DIY
- Admin, finances, organising
- Shopping, errands
- Waiting, queueing
- Childcare, playing with children
- Pet care, playing with pets
- Care or help for adults
- Sleeping, resting, relaxing
- Sick in bed
- Meditating, religious activities
- Washing, dressing, grooming
- Intimacy, making love
- Talking, chatting, socialising
- Eating, snacking
- Drinking tea/coffee
- Drinking alcohol
- Smoking
- Texting, email, social media
- Browsing the Internet
- Watching TV, film
- Listening to music
- Listening to speech/podcast
- Reading
- Theatre, dance, concert
- Exhibition, museum, library
- Match, sporting event
- Walking, hiking
- Sports, running, exercise
- Gardening, allotment
- Birdwatching, nature watching
- Hunting, fishing

- Computer games, iPhone games
- Other games, puzzles
- Gambling, betting
- Hobbies, arts, crafts
- Singing, performing
- Something else

Next >

BY DEFAULT, THIS DIGITAL CAMERA SCREEN IS SHOWN ONLY WHEN OUTDOORS

Please take a photo straight ahead

Or tap Cancel to skip this step

THIS SCREEN IS SHOWN ONLY IF A PHOTO WAS TAKEN

Map

Add this photo to the public map?

Yes >

No >

THIS SCREEN IS SHOWN ONLY WHEN OUTDOORS AND IN THE RARE EVENT THAT GPS LOCATION ACCURACY IS STILL WORSE THAN 100M. IT ADVANCES AUTOMATICALLY WHEN ACCURACY REACHES 100M OR A PERIOD OF 60 SECONDS HAS ELAPSED.

Location

Improving location accuracy

Skip >

THE SURVEY DISMISSES ITSELF IMMEDIATELY AFTER THIS SCREEN IS DISPLAYED

Finished

Thank you!

Appendix Table A1: Count of Mappiness Responses and Respondents Exposed to TRIs by Time and Space

	Model 1			Model 2			Model 3			Model 4		
	5km	5km	5km	10km	10km	10km	20km	20km	20km	anywh	anywh	anywh
	24h	24h72h	72h7d	24h	24h72h	72h7d	24h	24h72h	72h7d	24h	24h72h	72h7d
Find	1524 (241)	2878 (262)	5330 (296)	2941 (295)	5311 (313)	9098 (347)	4761 (334)	8294 (352)	13815 (384)	11749 (405)	18112 (407)	25029 (428)
Bombing	344 (99)	600 (119)	1203 (154)	587 (141)	1165 (179)	2321 (229)	1078 (214)	2141 (250)	4062 (288)	4413 (330)	7774 (350)	13178 (385)
Shooting	252 (99)	477 (109)	928 (126)	461 (144)	967 (169)	1831 (176)	678 (175)	1364 (197)	2613 (211)	2529 (309)	4934 (328)	9631 (361)
Paramilitary shooting	489 (141)	822 (152)	1612 (176)	870 (189)	1562 (197)	2828 (221)	1146 (219)	2092 (225)	3675 (240)	2652 (310)	4943 (314)	8201 (314)
Paramilitary assault	361 (107)	682 (127)	1376 (161)	714 (144)	1377 (183)	2678 (208)	1414 (226)	2757 (278)	5279 (304)	3157 (313)	5985 (357)	10682 (393)
Incendiary	8 (4)	10 (4)	9 (4)	10 (6)	16 (6)	31 (10)	14 (7)	24 (8)	49 (13)	50 (26)	111 (30)	225 (38)
Death	11 (7)	23 (8)	53 (15)	14 (9)	36 (15)	87 (23)	21 (14)	47 (18)	110 (26)	38 (21)	83 (24)	174 (31)

N responses (N users)

Appendix Table A2: TRIs Resulting in Death (RHS), and Momentary Happiness (LHS)								
	5km		10km		20km		Anywhere	
response_seq	-0.00+	(0.00)	-0.00+	(0.00)	-0.00+	(0.00)	-0.00+	(0.00)
Day of week	.	.	.	.	.	.	.	.
Monday	-1.09	(0.87)	-1.10	(0.87)	-1.11	(0.87)	-1.04	(0.87)
Tuesday	-0.57	(0.99)	-0.58	(0.99)	-0.61	(0.99)	-0.51	(0.99)
Wednesday	0.15	(0.93)	0.13	(0.93)	0.11	(0.94)	0.21	(0.94)
Thursday	0.15	(0.90)	0.14	(0.90)	0.11	(0.90)	0.21	(0.91)
Friday	0.89	(0.67)	0.88	(0.67)	0.86	(0.67)	0.92	(0.68)
Saturday	0.55	(0.53)	0.55	(0.53)	0.55	(0.53)	0.55	(0.53)
Hour of day	.	.	.	.	.	.	.	.
6am to 9am	-6.57**	(1.35)	-6.56**	(1.35)	-6.55**	(1.34)	-6.53**	(1.34)
9am to noon	-4.18**	(1.13)	-4.17**	(1.13)	-4.17**	(1.13)	-4.16**	(1.13)
Noon to 3pm	-2.87**	(1.08)	-2.86**	(1.08)	-2.86**	(1.08)	-2.84**	(1.08)
3pm to 6pm	-2.33*	(1.03)	-2.32*	(1.03)	-2.31*	(1.03)	-2.30*	(1.03)
6pm to 9pm	0.08	(0.98)	0.08	(0.98)	0.09	(0.98)	0.11	(0.98)
9pm to midnight	1.78+	(0.96)	1.79+	(0.96)	1.80+	(0.96)	1.81+	(0.96)
GB happiness	65.60**	(18.56)	65.38**	(18.55)	65.04**	(18.55)	66.59**	(18.60)
t24h	-6.26	(3.90)	-5.20+	(3.16)	-4.51	(2.74)	-3.24	(2.46)
t24h72h	-12.59**	(4.79)	-7.99*	(3.59)	-7.83**	(2.83)	-3.78+	(2.06)
t72h7d	1.07	(2.60)	1.45	(2.13)	1.28	(1.77)	-1.48	(1.80)
_cons	67.54**	(1.17)	67.55**	(1.18)	67.56**	(1.17)	67.50**	(1.18)
<i>N obs</i>	30015		30015		30015		30015	
<i>N groups</i>	445		445		445		445	
<i>R2 (within)</i>	0.03		0.03		0.03		0.03	
<i>F(17,444)</i>	10.60		10.40		10.59		10.44	
Standard errors in parentheses								
+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$								

