**Classification:** SOCIAL SCIENCES/Social Sciences

**Title:** Psychological Targeting as an Effective Approach to Digital Mass Persuasion

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**Author Contribution:** S.M. and M.K. developed the research idea, S.M., D.J.S., and M.K. designed the research; S.M. performed the analysis; S.M., M.K., and D.J.S. collected and cleaned the data; S.M., M.K., G.N., and D.J.S. wrote the paper.

**Datasets and Script are made available to reviewers on OSF.io:**

https://osf.io/srjv7/?view_only=90316b0c2e06420bbc3a1cc857a9e3c7

**Conflict of Interest:**

D.S. received revenue as the owner of the myPersonality Facebook application until it was discontinued in 2012. Revenue was received from displaying ads within the application and charging for a premium personality test. The revenue received by D.S. was unrelated to the studies presented in this paper, and there will be no future revenue generated from the application. None of the authors received any compensation for working on the marketing campaigns used to collect data for the studies presented in this manuscript.

**Abstract**

People are exposed to persuasive communication across many different contexts: governments, companies, and political parties use persuasive appeals to encourage people to eat healthier, purchase a particular product, or vote for a specific candidate. Laboratory studies show that such persuasive appeals are more effective in influencing behavior when they are tailored to individuals' unique psychological characteristics. Yet, the investigation of large-scale psychological persuasion in the real world has been hindered by the questionnaire-based nature of psychological assessment. Recent research, however, shows that people's psychological characteristics can be accurately predicted from their digital footprints, such as their Facebook Likes or Tweets. Capitalizing on this new form of psychological assessment from digital footprints, we test the effects of psychological persuasion on people's actual behavior in an ecologically valid setting. In three field experiments that reached over 3.5 million individuals with psychologically-tailored advertising, we find that matching the content of persuasive appeals to individuals' psychological characteristics significantly altered their behavior as measured by clicks and purchases. Persuasive appeals that were matched to people's extraversion or openness-to-experience level resulted in up to 40% more clicks and up to 50% more purchases than their mismatching or un-personalized counterparts. Our findings suggest that the application of psychological targeting makes it possible to influence the behavior of large groups of people by tailoring persuasive appeals to the psychological needs of the target audiences. We discuss both the potential benefits of this method for helping individuals make better decisions and the potential pitfalls related to manipulation and privacy.

**Significance Statement**

Building on recent advancements in the assessment of psychological traits from digital footprints, this paper demonstrates the effectiveness of psychological mass persuasion – that is, the adaptation of persuasive appeals to the psychological characteristics of large groups of individuals with the goal of influencing their behavior. On the one hand, this new form of psychological mass persuasion could be used to help people make better decisions, and lead healthier and happier lives. On the other hand, it could be used to covertly exploit weaknesses in their character and persuade them to take action against their own best interest, highlighting the potential need for policy interventions.

Persuasive mass communication is aimed at encouraging large groups of people to believe and act on the communicator's viewpoint. It is used by governments to encourage healthy behaviors, by marketers to acquire and retain consumers, and by political parties to mobilize the voting population. Research suggests that persuasive communication is particularly effective when tailored to people's unique psychological characteristics and motivations (1–5), an approach that we refer to as *psychological persuasion*. The proposition of this research is simple, yet powerful: What convinces one person to behave in a desired way might not do so for another. For example, matching computer-generated advice to participants' dominance level elicited higher ratings of source credibility, and increased the likelihood of participants changing their initial opinions in response to the advice (2). Similarly, participants' positive attitudes and purchase intentions were stronger, when the marketing message for a mobile phone was tailored to their personality profile (4). While these studies provide promising evidence for the effectiveness of psychological persuasion, their validity is limited by the fact that they were mainly conducted in small-scale, controlled laboratory settings using self-report questionnaires. Self-reports are known to be affected by a whole range of response biases (6), and there are numerous reasons why people's natural behavior might differ from that displayed in the laboratory (7). Consequently, it is questionable whether – and to what extent – these findings can be generalized to the application of psychological persuasion in real-world mass persuasion (see 8 for initial evidence).

A likely explanation for the lack of ecologically valid research in the context of psychological persuasion is the questionnaire-based nature of psychological assessment. Whereas researchers can ask participants to complete a psychological questionnaire in the laboratory, it is unrealistic to expect millions of people to do so before sending them persuasive messages online. Recent research in the field of computational social sciences (9), however, suggests that people's psychological profiles can be accurately predicted from the digital footprints they leave with every step they take online (10). For example, people's personality profiles have been predicted from personal websites (11), blogs (12), Twitter messages (13), Facebook profiles (10, 14-16), and Instagram pictures (17). This new form of *psychological assessment from digital footprints* makes it paramount to establish the extent to which behaviors of large groups of people can be influenced through the application of psychological mass persuasion – both in their own interest (e.g., by persuading them to eat healthier) and against their best interest (e.g., by persuading them

to gamble). We begin this endeavor in a domain that is relatively uncontroversial from an ethical point of view: consumer products.

Capitalizing on the assessment of psychological traits from digital footprints, we conducted three real-world experiments that reached more than 3.7 million people. Our experiments demonstrate that targeting people with persuasive appeals tailored to their psychological profiles can be used to influence their behavior as measured by clicks and conversions.[1] The experiments were run using Facebook advertising, a typical behavioral targeting platform. As of now, Facebook advertising does not allow marketers to directly target users based on their psychological traits. However, it does so indirectly by offering the possibility to target users based on their Facebook Likes[2] . For example, if liking "Socializing" on Facebook correlates with the personality trait of extraversion, and liking "Stargate" goes hand in hand with introversion, then targeting users associated with each of these Likes allows one to target extraverted and introverted user segments (see SI Appendix for a validation of this method).

Studies 1 and 2 target individuals based on their psychological traits of extraversion and openness-to-experience (18, 19). We chose these two because they show strong associations with Facebook Likes (14), and have been frequently investigated in the context of consumer preferences and persuasive communication (e.g. 2). We extracted lists of Likes indicative of high and low levels of each of these traits from the *myPersonality.org* database (20). MyPersonality contains the Facebook Likes of millions of users alongside their scores on the 100-item IPIP questionnaire, a widely validated and used measure of personality (19). We computed the average personality trait levels for each Like, and selected 10 Likes characterized by the highest and lowest aggregate extraversion and openness scores (i.e. *target Likes*). For example, the list of introverted target Likes included "Stargate" and "Computers", while the list of extraverted target Likes contained "Making People Laugh" or "Slightly Stoopid". The list of target Likes for low openness included "Farm Town" and "Uncle Kracker", while the list for high openness contained

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[1] Click-through rates (CTRs) is a commonly used digital marketing metric that quantifies the number of clicks relative to number of times the ad was shown. Conversion rate is a marketing metric that reflects number of conversions, such as app downloads or online store purchases, relative to the number of times the ad was shown.
[2] Facebook users can like content such as Facebook Pages, Posts, or photos to express their interest in a wide range of subjects, such as celebrities, politicians, books, products, brands, etc. Likes are therefore similar to a wide range of other digital footprints—such as web-browsing logs, purchase records, playlists, and many others. Hence, the findings based on Facebook Likes are likely to generalize to digital footprints employed by other advertising platforms.

"Walking Life" and "Philosophy" (for the full lists of target Likes see SI Appendix, Tables S1 and S6). Study 3 builds on the findings of Studies 1-2, and shows how psychological persuasion can be used in the context of predefined behavioral audiences.

## Results

**Study 1** demonstrates the effects of psychological persuasion on people's purchasing behavior. We tailored the persuasive advertising messages for a UK-based beauty retailer to recipients' extraversion, a personality trait reflecting the extent to which people seek and enjoy company, excitement and stimulation (18). People scoring high on extraversion are described as energetic, active, talkative, sociable, outgoing, and enthusiastic; people scoring low on extraversion are characterized as shy, reserved, quiet, or withdrawn. Given the specific nature of the product, we only targeted women. Figure 1a displays two (out of 10) ads aimed to appeal to women characterized by high versus low extraversion (we refer to the personality of the audience an ad is aimed at as *ad personality*). Using a 2 (ad personality: introverted vs. extraverted) × 2 (audience personality: extraverted vs. introverted) between-subjects, full-factorial design, we ran the Facebook advertising campaign over the course of seven days – that is, we placed the ads on viewers' Facebook pages as they browsed freely.

**Figure 1.** Examples of ads aimed at audiences characterized by high and low extraversion (A) as well as high and low openness (B).



1a

High Extroversion — Low Extroversion

Love the spotlight and feel the moment — Beauty doesn't have to shout

1b

High Openness — Low Openness

LOADS OF WORDS

Aristoteles? The Seychelles? Unleash your creativity and challenge your imagination with an unlimited number of crossword puzzles! — Settle in with an all-time favorite! The crossword puzzle that has challenged players for generations.

Together, the campaign reached 3,129,993 users, attracted 10,346 clicks, and resulted in 390 purchases on the beauty retailer's website. Table 1 (top) provides a detailed overview of the descriptive campaign statistics across ad sets (see SI Appendix for more detailed breakdowns). We conducted hierarchical logistic regression analyses for clicks (click = 1, no click = 0) and conversions (conversion = 1, no conversion = 0), using the audience personality, the ad personality and their two-way interaction as predictors.[3] Users were more likely to purchase after viewing an ad that matched their personality (Fig. 2; audience personality × ad personality interaction; B = 0.90, SE(B) = 0.21, $z$ = 4.30, $p$ < 0.001). These effects were robust after controlling for age and its interactions with ad personality. Averaged across the campaigns, users in the congruent conditions were 1.54 times more likely to purchase from the online store than users in the incongruent conditions ($\chi^2$ (1) = 17.72; OR = 1.54 [1.25-1.90], $p$ < 0.001). There was no significant interaction effect on clicks ($\chi^2$ (1) = <0.001; OR = 1.0 [0.96-1.04], $p$ = 0.98).

**Table 1.** Descriptive statistics of Studies 1-3 across ad sets. CTR = Click-through Rate (clicks/reach*100), CR = Conversion Rate (installs/reach*100), CPConv = Cost per conversion, ROI = Return on Investment (profits/spending*100).

| | | | | | **Study 1** | | |
|---|---|---|---|---|---|---|---|
| Condition | Reach | Clicks | CTR | Conv | CR | CPConv | ROI |
| Introverted Ads congruent | 762,197 | 2,637 | 0.35% | 121 | 0.016% | £7.80 | 409% |
| Introverted Ads incongruent | 791,270 | 2,426 | 0.31% | 90 | 0.011% | £10.41 | 300% |
| Extraverted Ads congruent | 814,308 | 2,573 | 0.32% | 117 | 0.014% | £8.32 | 410% |
| Extraverted Ads incongruent | 762,218 | 2,710 | 0.36% | 62 | 0.008% | £15.93 | 219% |
| **Total** | **3,129,993** | **10,346** | **0.33%** | **390** | **0.012%** | **£9.85** | **334%** |
| | | | | | **Study 2** | | |
| High Openness Ad congruent | 29,277 | 427 | 1.45% | 140 | 0.48% | $2.29 | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High Openness Ad incongruent | 8,926 | 112 | 1.25% | 37 | 0.41% | $2.71 | - |
| Low Openness Ad congruent | 18,210 | 296 | 1.62% | 174 | 0.96% | $1.38 | - |
| Low Openness Ad incongruent | 27,763 | 295 | 1.06% | 149 | 0.53% | $1.76 | - |
| **Total** | **84,176** | **1,130** | **1.34%** | **500** | **0.59%** | **$1.85** | **-** |
| | | | **Study 3** | | | | |
| Standard copy | 324,770 | 1,830 | 0.56% | 1,053 | 0.32% | $3.21 | - |
| Personality-tailored copy | 209,480 | 1,537 | 0.73% | 784 | 0.37% | $2.91 | - |
| **Total** | **534,250** | **3,367** | **0.63%** | **1,837** | **0.34%** | **$3.10** | **-** |

Note: CTR = Click-through Rate (clicks/reach*100), CR = Conversion Rate (installs/reach*100), CPConv = Cost per conversion, ROI = Return on Investment (profits/spending*100).

**Study 2** replicates and extends the findings of Study 1 by tailoring the persuasive advertising messages for a crossword app to recipients' level of openness, a personality trait reflecting the extent to which people prefer novelty over convention (18). People scoring high on openness are described as intellectually curious, sensitive to beauty, individualistic, imaginative, and unconventional. People scoring low on openness are traditional and conservative, and are likely to prefer the familiar over the unusual. Using the same targeting approach and experimental design as Study 1, we created tailored advertising messages for both high and low openness (Fig. 1, bottom half). The campaign was run on Facebook, Instagram and Audience Networks for twelve days.

**Figure 2.** Interaction effects of audience and ad personality on conversion rates in Study 1 (left) and Study 2 (right).
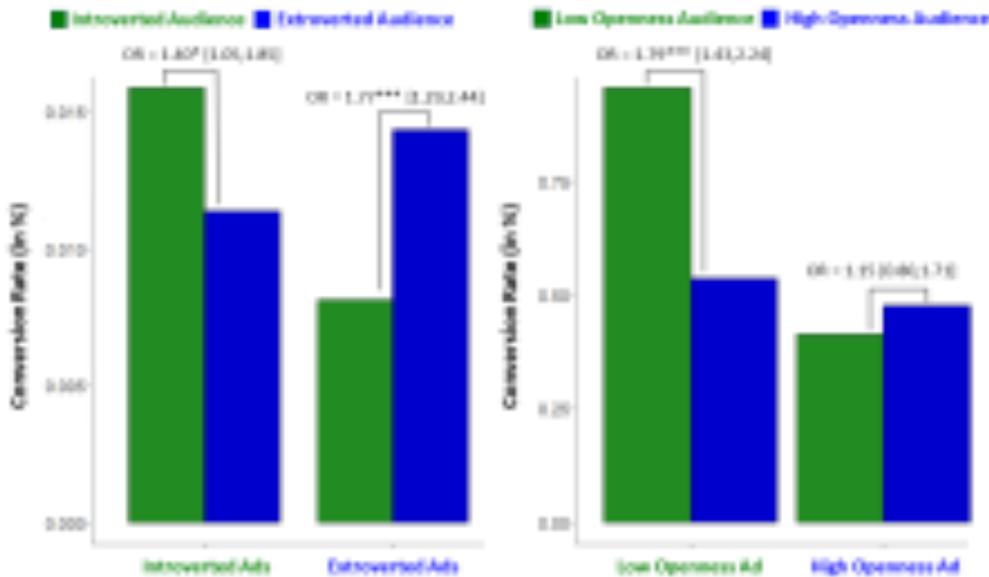


The campaign reached 84,176 users, attracted 1,130 clicks, and resulted in 500 app installs. Table 1 (middle) provides a detailed overview of the descriptive campaign statistics across ad sets (see SI Appendix for more detailed breakdowns). Using the same hierarchical logistic regression analyses as in Study 1, we found significant interaction effects of audience personality and ad personality on both clicks (B = 0.58, SE(B) = 0.14, $z$ = 4.31, $p$ < 0.001) and conversions (Figure 2; B = 0.72, SE(B) = 0.22, $z$ = 3.35, $p$ < 0.001). These effects were robust after controlling for age, gender, and their interactions with ad personality. Averaged across the campaigns, users in the congruent conditions were 1.38 times more likely to click ($\chi^2$ (1) = 26.68; OR = 1.38 [1.22-1.56], $p$ < 0.001) and 1.31 times more likely to install the app ($\chi^2$ (1) = 8.34; OR = 1.31 [1.09-1.58], $p$ = 0.004) than users in the incongruent conditions. As Figure 2 illustrates, the significant interaction effect on installs was mainly driven by the target audiences characterized as low Openness. While people scoring low on openness installed the app significantly more often when presented with the matching marketing message ($\chi^2$ (1) = 22.72; OR = 0.43 [0.29-0.62], $p$ < 0.001), there was no significant difference in install rates to matching versus mismatching messages among people scoring high on openness ($\chi^2$ (1) = 0.97; OR = 0.89 [0.70-1.13], $p$ = 0.325).

**Study 3** builds on the findings of Studies 1-2, and shows how psychological persuasion can be used in the context of predefined audiences (e.g., when marketers have already established a behavioral target group, or when health promotions are targeted at a specific subpopulation at risk). Promoting a bubble shooter game, we followed the company's pre-existing behavioral targeting approach and targeted the game at Facebook users who were connected with a selected list of similar games (e.g., Farmville or Bubble Popp). Mapping these behavioral target Likes onto those available within the myPersonality database allowed us to identify the psychological profile of this audience. Building on the finding that the target audience was highly introverted ($\overline{E_z} = -0.25$), we promoted the app comparing the company's standard persuasive advertising message ("Ready? FIRE! Grab the latest puzzle shooter now! Intense action and brain-bending puzzles!") to a psychologically-tailored one ("Phew! Hard day? How about a puzzle to wind down with?"). Both campaigns were run over the course of seven days on Facebook.

Together, the campaign reached 534,250 users, attracted 3,173 clicks, and resulted in 1,837 app installs. Table 1 (bottom) provides a detailed overview of the descriptive campaign statistics across ad sets. Corresponding to our hypothesis, two Chi-square tests showed that the psychologically-tailored ad set attracted significantly more clicks ($\chi^2$ (1) = 58.66; OR = 1.30 [1.22-1.40], $p < 0.001$) and installs ($\chi^2$ (1) = 9.16; OR = 1.15 [1.05-1.27], $p = 0.002$) than the standard ad set. Click-through and conversion rates were 1.3 and 1.2 times higher when the persuasive advertising message was tailored to the psychological profile of the pre-existing behavioral audience (see SI Appendix for evidence that this effect is not exclusively due to the fact that the tailored advertising message was generally more appealing).

## Discussion

The results of the three studies provide converging evidence for the effectiveness of psychological targeting in the context of real-life digital mass persuasion; tailoring persuasive appeals to the psychological profiles of large groups of people allowed us to influence their actual behaviors and choices. Given that we approximated people's psychological profiles using a single Like per person – instead of predicting individual profiles using people's full history of digital

footprints (eg. 10,14) – our findings represent a conservative estimate of the potential effectiveness of psychological mass persuasion in the field.

The effectiveness of large-scale psychological persuasion in the digital environment heavily depends on the accuracy of predicting psychological profiles from people's digital footprints (whether in the form of machine learning predictions from a user's behavioral history, or single target Likes), and therefore this approach is not without limitations. First, the psychological meaning of certain digital footprints might change over time, making it necessary to continuously calibrate and update the algorithm in order to sustain high accuracy. For example, liking the fantasy TV show "Game of Thrones" might have been highly predictive of introversion when the series was first launched in 2011, but its growing popularity might have made it less predictive over time as its audience became more mainstream. As a rule of thumb, one can say that the higher the face validity of the relationships between individual digital footprints and specific psychological traits, the less likely it is that they will change (e.g. it is unlikely that "socializing" will become any less predictive of extraversion over time). Second, while the psychological assessment from digital footprints makes it possible to profile large groups of people without requiring them to complete a questionnaire, most algorithms are developed with questionnaires as the gold standard and therefore retain some of the problems associated with self-report measures (e.g. social desirability bias; 22).

Additionally, our study has limitations that provide promising avenues for future research. First, we focused on the two personality traits of extraversion and openness-to-experience. Building on existing laboratory studies, future research should empirically investigate whether and in which contexts other psychological traits might prove to be more effective (e.g. need for cognition, 2; or regulatory focus, 23). Second, we conducted extreme group comparisons where we targeted people scoring high or low on a given personality trait using a relatively narrow and extreme set of Likes. While the additional analyses reported in the SI Appendix suggest that less extreme Likes still enable accurate personality targeting, future research should establish whether matching effects are linear throughout the scale, and if not, where the boundaries of effective targeting lie.

The capacity to implement psychological mass persuasion in the real world carries both opportunities and ethical challenges. On the one hand, psychological persuasion could be used to

help individuals make better decisions and alleviate many of today's societal ills. For example, psychologically-tailored health communication is effective in changing behaviors among patients and groups that are at risk (24, 25). Hence, targeting highly neurotic individuals who display early signs of depression with materials that offer them professional advice or guide them to self-help literature might have a positive preventive impact on the well-being of vulnerable members of society. On the other hand, psychological persuasion might be used to exploit "weaknesses" in a person's character. It could, for instance, be applied to target online casino advertisements at individuals who have psychological traits associated with pathological gambling (26). In fact, recent media reports suggest that one of the 2016 US presidential campaigns used psychological profiles of millions of US citizens to suppress their votes and keep them away from the ballots on election day (27). The veracity of this news story is uncertain (28). However, it illustrates clearly how psychological mass persuasion could be abused to manipulate people to behave in ways that are neither in their best interest nor in the best interest of society.

Similarly, the psychological targeting procedure described in this manuscript challenges the extent to which existing and proposed legislation can protect individual privacy in the digital age. While previous research shows that having direct access to an individual's digital footprint makes it possible to accurately predict intimate traits (10), the current study demonstrates that such inferences can be made even without having direct access to individuals' data. Although we used indirect group-level targeting in a way that was anonymous at the individual level and thus preserved—rather than invaded— participant's privacy, the same approach could also be used to reveal individuals' intimate traits without their awareness. For example, a company could advertise a link to a product or a questionnaire on Facebook, targeting people who follow a Facebook Like that is highly predictive of introversion. Simply following such a link reveals the trait to the advertiser, without the individual being aware that they have exposed this information. To date, legislative approaches in the U.S. and Europe have focused on increasing the transparency of how information is gathered and ensuring that consumers have a mechanism to "opt out" of tracking (29). Crucially, none of the measures currently in place or in discussion address the techniques described in this paper: our empirical experiments were performed without collecting any individual-level information whatsoever on our subjects, yet revealed personal information that many would consider deeply private. Consequently, current approaches

are ill equipped to address the potential abuse of online information in the context of psychological targeting.

As more behavioral data is collected in real time, it will become possible to put people's stable psychological traits in a situational context. For example, people's mood and emotions have been successfully assessed from spoken and written language (30), video (31), or wearable devices and smartphone sensor data (32). Given that people who are in a positive mood use more heuristic - rather than systematic - information processing and report more positive evaluations of people and products (33), mood could indicate a critical time period for psychological persuasion. Hence, extrapolating from what one does to who one is, is likely just the first step in a continuous development of psychological mass persuasion.

**Methods**

Ethical approval was granted by the Department of Psychology Ethics Committee at the University of Cambridge. Given that the group-level targeting approach applied in Studies 1-3 is 100% anonymous on the individual level (all insights provided by Facebook are summary statistics at the level of target groups), it is impossible to identify, interact with and obtain consent from individual participants.

 **Study 1.** *Selection of Target Likes.* The myPersonality dataset was collected via the myPersonality Facebook app between 2007 and 2012 (20). Mostly free of charge, the app allowed its users to take real psychometric tests. Among other validated tests, users could choose between several versions of the International Personality Item Pool (IPIP) questionnaire, an established open-source measure of the five factor model of personality (19).  The five factor model has been shown to have excellent psychometric properties, including high reliability, convergent and discriminant validity, as well as robust criterion validity when predicting real-life outcomes (18,19). Users received immediate feedback on their responses and were encouraged to grant the application access to their personal profile and social network data.

Study 1 used a myPersonality subsample that contained 65,536 unique Facebook Likes alongside the average personality profile of US-based users connected to those Likes. The extraversion score of the Facebook Like "Lady Gaga", for example, was determined by averaging the $z$-standardized extraversion scores of all users in the sample who had liked "Lady Gaga". To

maximize the reliability of personality profiles and limit the biases introduced by differences in traits other than extraversion, we further restricted the dataset described above to Likes followed by at least 400 users and only considered Likes that were neutral with respect to the remaining four traits ($|z| < 0.20\sigma$). We finally selected those Likes with the highest ($\bar{z}_E = 0.54\sigma, n = 8$) and lowest aggregate extraversion scores ($\bar{z}_E = -0.20\sigma, n = 8$) that were available in the Facebook Interest section at the time. Table S1 in the SI Appendix displays the Likes used to target extraverted and introverted audiences alongside their personality scores and sample sizes.

*Advert Design*. Professional graphic designers created five ads aimed at introverts and five ads aimed at extraverts by manipulating the language and images used in the advert design. The five extraverted adverts were based on trait descriptions such as "active, assertive, energetic, enthusiastic, outgoing and talkative" whereas the introverted adverts reflected trait descriptions such as "quiet, reserved, shy, silent, and withdrawn" (18). All ads are displayed in Figure S2 in the SI Appendix. We validated the manipulation of advert designs by surveying 38 female judges (16 post-graduate students at the University of Cambridge Psychology Department, and 22 students with no formal training in psychology). Independent t-tests confirmed that both psychologists and laymen perceived extraverted ads to be more extraverted than the introverted ads (psychologists: t(196) = 24.77, $p < 0.001$, $d = 3.51$ [3.07,3.96]; laymen: t(220) = 15.30, $p < 0.001$, $d = 2.05$ [1.73,2.38]).

*Targeting Procedure.* We created "introverted" and "extraverted" market segments by entering the selected target Likes displayed in Table S1 in the SI Appendix into the "Interest" section of the Facebook advertising platform. This procedure allowed us to limit the advert recipients to users who were associated with at least one of our target Likes. At the time the study was conducted, the Facebook advertising platform only allowed marketers to enter multiple Likes with OR rather than AND statements. For example, an extraverted target audience could be created with users who like "Making People Laugh" OR "Meeting New People", but not with users who like both. Therefore, the targeting approach pursued in this paper was based on the minimum amount of information possible: one single Facebook Like per person. In addition to the target Likes outlined above the ad sets were restricted to female UK residents aged 18-40.

**Study 2.** *Targeting Procedure.* Similar to Study 1, we selected those Likes with the highest ($\bar{z}_O = 0.59\sigma, n = 10$) and lowest aggregate openness scores ($\bar{z}_O = -0.50\sigma, n = 10$) that were

available in the Facebook Interest section at the time. In addition to the targeting specifications outlined in the main manuscript we restricted our ad sets to US residents who were connected to a wireless network at the time of seeing the ads to facilitate app installs. Table S6 in the SI Appendix displays the Likes used to target audiences low and high in openness alongside their personality scores and sample sizes.

*Ad Design.* Professional graphic designers and copy editors created two adverts tailored to high and low openness characteristics by manipulating the language and images used in the advert design. While the low-openness advert was based on trait descriptions such as "down to earth, traditional and conservative" the high-openness advert reflected trait descriptions such as "intellectually curious, creative, imaginative, and unconventional" (17). We validated the manipulation of advert designs by surveying 22 students at the University of Cambridge (average age = 23.5 years, 50% female). An independent t-test confirmed that participants perceived the high-openness ad to be more open-minded than the low-openness ad (t(42) = -4.28, $p < .001$, $d = 1.29$ [0.62,1.96]).

**Study 3.** *Targeting Procedure.* Following the company's standard behavioral targeting approach, ad sets were aimed at women aged 35 and above, living in the US, who were connected to at least one of the mobile games on the company's behavioral target list. We further restricted our ad sets to US residents who were connected to a wireless network at the time of seeing the ads, in order to facilitate app installs.

*Ad Design.* Professional copy-writers produced an introverted (personality-tailored) ad text that we subsequently compared to the standard ad text (the image that was used to advertise the app was kept constant). The two ad versions are displayed in Table S9 in the SI Appendix. We validated the manipulation of ad designs by surveying 22 students at the University of Cambridge (average age = 23.5 years, 50% female). An independent t-test confirmed that participants perceived the personality-tailored ad to be more introverted than the standard ad (t(41) = -2.77, $p = .008$, $d = 0.84$ [0.20,1.48]).

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