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Happier individuals generate more spontaneous thoughts about friends and value relationships over money

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Spontaneous thoughts are a window into one's mind, as they offer rich information about ongoing psychological processes and value systems. We accessed the contents of these thoughts using a free association paradigm combined with natural language processing techniques to examine how happiness is associated with what people think about and prioritize in daily life. Our analyses revealed that participants ($n = 210$ from the US/UK) with higher subjective well-being, particularly those with more frequent positive affect, generated thoughts semantically more similar to 'friend,' but not to 'money.' A similar pattern was also found in an independent sample ($n = 350$ from South Korea), showing consistency of the findings across different cultural contexts. Notably, the semantic similarity of participants' generated thoughts to 'friend' predicted the extent to which participants prioritized social relationships over monetary gains in a realistic dilemma task. By exploring individuals' minds with a computational approach, our work elucidates how the value of social relationships is manifested in spontaneous thought contents and everyday decisions, providing insights into the sources of happiness.

In the pursuit of understanding the human mind, a compelling approach is to examine the contents of spontaneous thoughts. Supporting classical theories that emphasize the importance of spontaneous thought processes in human behavior and decision making^{1,2}, recent studies suggest that spontaneous thoughts are not random but self-relevant in nature, offering a lens into the human mind^{3–5}. Researchers have shown that the contents of self-generated thoughts captured by associative semantic networks can reveal one's current mental states, reflecting past and ongoing experiences, future goals, personal values, and implicit attitudes^{2,6–8}. Yet, despite growing interest in the nature and function of spontaneous thought, it remains unclear how specific thought contents reveal individual differences in well-being.

To address this, the present study examines how specific contents of self-generated thoughts that occupy one's mind are related to individual differences in happiness. We combined the Free Association Semantic Task (FAST)^{6,9}—which indexes spontaneous thought tendencies through patterns of conceptual association—with a natural language processing

technique (Word2vec)¹⁰ to capture semantic associations in each individual's thought stream. Here, we focused on thoughts related to 'friend' and 'money' as representative examples of these domains, as the interpersonal and monetary domains are among the most relevant to one's happiness^{11–13}. Specifically, social connections are not only essential for human survival but also crucial for one's well-being^{14–18}. Previous findings consistently indicate that positive social relationships are among the most important predictors of happiness^{13,19}, as well as the most prominent characteristics of happy individuals¹². Evidence also has documented an association between money and happiness^{20–23}, including cross-national evidence¹¹. Building on this, we sought to examine how these two concepts, 'friend' and 'money,' are represented within one's mental landscape and how such representations relate to happiness across individuals.

As the extensive body of literature supporting the overarching role of social relationships in happiness^{14,15,17,24} implies that happier individuals might be more likely to think about social connections and friendships than less happy individuals, we predicted that higher levels of happiness would be

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associated with greater conceptual associations with ‘friend.’ On the other hand, the strength and nature of the relationship between money and happiness (e.g., whether linear or curvilinear) vary across different baselines and dimensions of well-being (e.g., cognitive or affective aspects of happiness)^{20,21,25}. Furthermore, the excessive pursuit of material values (e.g., materialism) is often negatively associated with happiness²⁶. These inconsistent findings led us to refrain from formulating a specific hypothesis regarding thoughts about money, opting instead for a more exploratory approach.

Then, would the individual differences in thought contents influence everyday decisions, which may, over time, cumulatively contribute to one’s happiness? Spontaneous thoughts reflect various cognitive and affective processes, and thereby can influence one’s preferences^{7,27,28}. If the generated thoughts of individuals reporting higher happiness are semantically closer to ‘friend,’ this may reflect stronger valuation of social relationships, as suggested by previous findings that happier individuals cherish and better utilize the benefits of social relationships^{29,30}. Therefore, we hypothesized that the degree of semantic association between participants’ generated thoughts and ‘friend’ would predict individuals’ choices between social relationships and monetary outcomes: such that greater association would be linked to a higher likelihood of preferring social gain over monetary gain.

To test our hypotheses, we combined measures of subjective well-being (SWB)³¹ with the FAST^{6,9}, in which participants generated consecutive concepts from seed words and then evaluated the valence, importance, and other- vs. self-relevance³² of the generated concepts. Each generated concept was vectorized to quantify semantic similarity and convergence to ‘friend’ or ‘money,’ allowing us to test whether greater happiness was associated with closer conceptual associations with ‘friend,’ whereas associations with ‘money’ were less prominent. We further examined the generalizability of this effect in an independent sample that had been collected prior to the present study^{9,33}. Finally, in a follow-up session with the main sample, participants completed a decision task that required trading off between social relationships and monetary rewards, enabling us to test whether stronger conceptual associations with ‘friend’ predicted a greater preference for social over monetary values.

Methods

Participants

All participants of the main data set were recruited through Prolific (<https://www.prolific.com/>). Based on a priori power analysis using G*Power³⁴, we calculated that to detect a moderate effect size ($f^2 = 0.2$) with 80% power at an alpha level of 0.05 in correlation studies, 191 participants were needed. Anticipating potential dropouts and aiming for robustness in our data analysis, we recruited 210 participants. Eligibility criteria included being a native English speaker, aged 18 to 35, and having no current mental health issues. The sample included 114 male participants (mean age = 28.211, $SD = 4.748$) and 96 female participants (mean age = 28.552, $SD = 4.783$); sex was self-reported. Ethnicity was reported as Asian ($n = 17$), Black ($n = 22$), Mixed ($n = 3$), Other ($n = 6$), and White ($n = 162$). Participants gave informed consent before their participation and received \$10 for the first session and \$8 for the second session as compensation. The Institutional Review Board at Pusan National University (no. 2023-49) approved all experimental protocols and methods. Data were collected in September 2023. This study was not preregistered.

To examine whether the observed pattern from the main sample extends across cultural contexts, we analyzed an independent sample of Korean participants drawn from previously collected data. This dataset comprised 350 participants recruited from two separate studies (137 participants in July 2019 and 213 participants in April 2020). A post hoc power analysis using G*Power³⁴ confirmed that this sample size was sufficient to detect a moderately large effect size ($f^2 = 0.2$) with 95% power at an alpha level of 0.05. Of the 350 participants, 171 were male participants (mean age = 22.357, $SD = 3.259$) and 179 were female participants (mean age = 23.184, $SD = 2.613$); sex was self-reported, and all were Asian. These studies were approved by Sungkyunkwan University’s Institutional Review Board (no.

2017-05-001-017 and 2019-06-004-008), with all participants providing written informed consent and receiving compensation for their participation. All descriptive statistics for the main and independent samples are presented in Supplementary Tables S1 and S2, respectively.

Experimental procedure

The main study was structured into two sessions (Fig. 1). In the first session, participants reported their level of SWB, which encompasses both cognitive and affective aspects by assessing positive affect (PA), negative affect (NA), and life satisfaction (LS). Subsequently, they engaged in FAST^{6,9}, which was designed to quantitatively analyze the contents and temporal patterns of participants’ generated concepts. After completing the first session, participants were invited to the second session within three days. Out of 210 participants, 192 successfully completed both sessions, with the average time interval between the sessions being 1 day and 3 hours. In the second session, participants were presented with a realistic dilemma in which the value of social relationships and monetary gains conflicted. In particular, participants were required to indicate the income increase that would make them willing to accept a lucrative job offer at the cost of sacrificing their close relationships. Additionally, participants filled out questionnaires measuring materialism and demographic information. FAST was implemented using jsPsych³⁵, and all experimental procedures were conducted online using their web browsers.

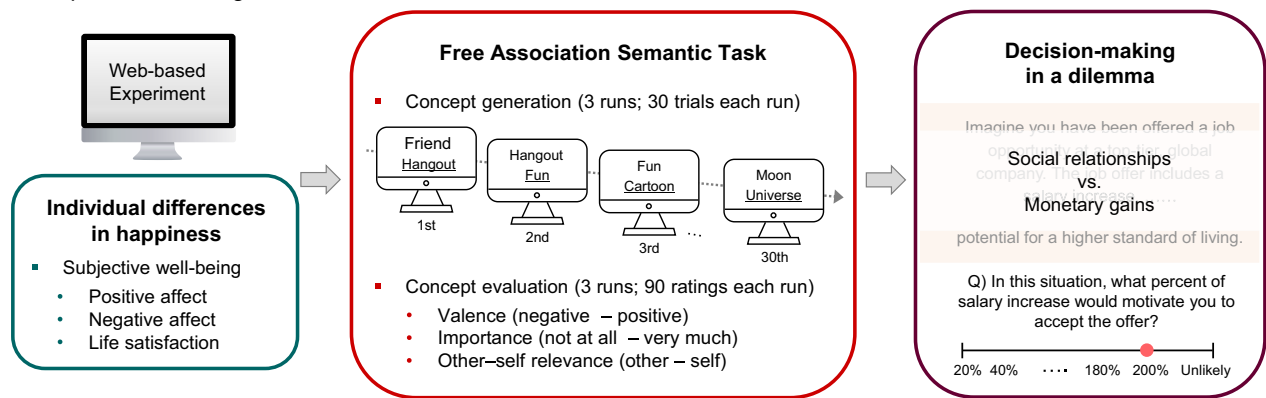
FAST

FAST consisted of two phases: a concept generation phase and a concept evaluation phase^{9,33}. In the concept generation phase, participants entered a word or short phrase that came to mind in response to a given seed word, and then proceeded to generate subsequent concepts or phrases in response to the previous concept they had generated every 7 seconds. They were asked to associate a total of 30 consecutive concepts, starting from each seed word. If participants did not provide a word or phrase within the 7-second interval, a warning appeared, and they were given an extra 4 seconds. This process repeated until they completed generating concepts. To provide context for the association between concepts, the screen displayed two consecutive concepts in sequence, with the second one enlarged to emphasize it as the focus of the trial during both phases. The concept generation phase included three blocks starting with three different seed words: a neutral word (“key”) and two priming words (“friend” and “money”), resulting in each participant generating a total of 90 concepts. The order of the seed words was randomized for each participant, while the neutral seed word was fixed first to avoid potential spillover effects.

After each generation block (30 concepts per seed word), participants immediately evaluated the 30 concepts they had just generated in the concept evaluation phase. They evaluated each concept on three dimensions, including emotional valence (i.e., what do you feel when you think about the word?), importance (i.e., how important does the word feel to you?), and other- vs. self-relevance (i.e., how much do you associate the word with yourself versus with others?), on 9-point scales from 1 (very negative; not at all important; completely relevant to self) to 9 (very positive; very important; completely relevant to others). Across the three blocks, participants thus evaluated all 90 concepts, resulting in a total of 270 ratings in the concept evaluation phase. These dimensions are known as core dimensions of self-generated thought contents³². With these measures, we explored how the concepts generated by happier participants could be characterized (e.g., more positive and other-relevant).

Similar to the main study, the independent sample engaged in the web-based FAST, which included two phases: concept generation and evaluation of the generated concepts. During the concept generation, each participant was asked to generate 40 consecutive concepts, starting with one of the seed words (“tear,” “family,” “mirror,” and “abuse”). Subsequently, participants evaluated the generated concepts based on valence, self-relevance, and time. As this data^{9,33} was not designed for the main study, the seed words and evaluation dimensions were different from ours. For confirmatory purposes,

A Experimental design



B Analytical strategy

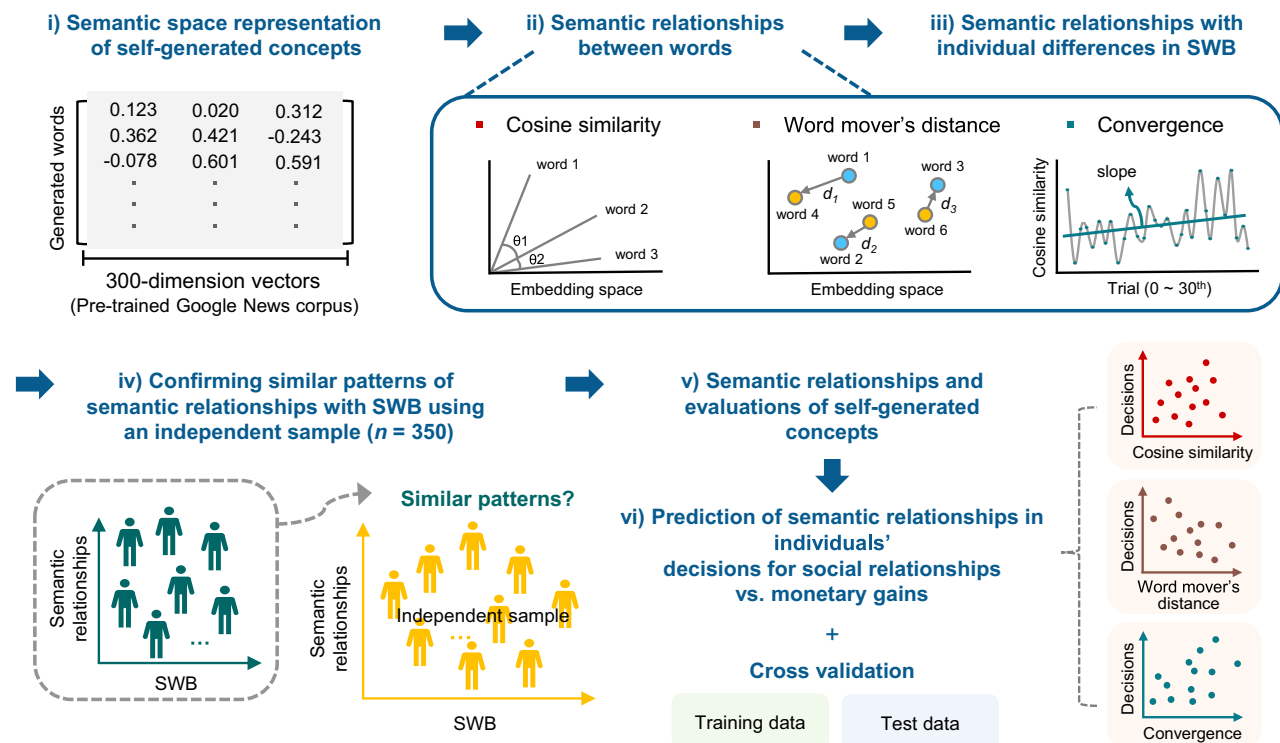


Fig. 1 | Overview of experimental design and analytical processes. **A** The study was conducted in two sessions. Initially, participants ($n = 210$) assessed their levels of SWB, including PA, NA, and LS, and then undertook FAST. FAST involved generating consecutive concepts from given seed words, including “friend,” “money,” and “key,” and evaluating these concepts across three dimensions: valence, importance, and other- vs. self-relevance. After the first session, they were invited to the second session within three days. In this second session, participants ($n = 192$) were presented with a realistic dilemma in which the values of social relationships and monetary gains conflicted, and were required to indicate the percentage of salary increase that would motivate them to accept the job offer, with options ranging in 20% intervals from 20% to 200%, or selecting ‘unlikely’ if no salary increase could justify the move (i.e., the extent to which they prioritized one value over the other). **B** To assess semantic relationships between participants’ generated concepts and the target concepts (i.e., ‘friend’ or ‘money’), we applied the Word2vec model, pre-

trained on the Google News corpus, and represented each concept as a 300-dimensional vector. The semantic similarity was quantified by calculating cosine similarity and WMD between the generated concepts and target concepts. These were computed through the cosine of the angle between one concept and another, and the minimal semantic distance required to transition from one concept set to another, respectively. We also analyzed how participants’ concepts increasingly aligned with ‘friend’ or ‘money’ across trials (i.e., convergence), using linear regression on individual cosine similarity values. Smoothed similarity functions captured the trend of alignment over time. Then, we validated our results using an independent sample ($n = 350$) for which data on SWB and FAST-related variables were available. Next, we investigated the relationship between SWB and evaluation scores on the generated concepts. Lastly, we examined whether the cosine similarity, WMD and convergence scores would predict participants’ decisions in the dilemma task.

we only used data from the concept generation phase and SWB measures (see Supplementary information for details). All concepts generated by these participants were originally in Korean and were translated into English for vectorization. Hereafter, double quotes indicate the seed words, while single quotes denote the target concept, unless specified otherwise.

Dilemma task: choice between social relationships and monetary gains

Participants in the main study were asked to carefully read a realistic dilemma scenario involving a choice between social relationships and monetary gains. The scenario contrasted accepting a lucrative job offer from

a top-tier global company at the cost of sacrificing their close relationships or maintaining the relationships with friends and family in their current location. The job offer included a salary increase, regular bonuses, and comprehensive financial benefits, whereas the close relationships provided emotional support, love, and a deep sense of belonging. The job required relocating to a different country, an 8-hour flight away, with uncertain prospects of returning home, thus presenting a conflict between interpersonal relationships and financial opportunity. After reading the scenario, participants were asked to indicate the percentage of salary increase that would make them willing to accept the job offer, with options ranging in 20% intervals from 20% to 200%, or selecting 'unlikely' if no salary increase could justify the move. This question aimed to quantitatively measure the extent to which participants placed value on close relationships over monetary gains. The scenario was previously evaluated in a pilot study ($n = 58$) based on its plausibility (mean = 69.446, $SD = 26.388$), psychological conflict between two options (mean = 68.333, $SD = 23.666$), and balanced representation of the two options (mean = 62.860, $SD = 26.430$), on a scale from 0 (not at all) to 100 (very much).

Questionnaires

We measured participants' PA and NA using the 12-item Scale of Positive and Negative Experience³⁶ and LS using the 5-item Satisfaction With Life Scale³⁷. As a measure of overall happiness, SWB scores were calculated by summing the standardized scores of PA, LS, and NA per participant (i.e., $PA + LS - NA$)^{29,30}. Demographic factors, including age, sex, education, and subjective socioeconomic status³⁸, were also measured. Additionally, to control for any potential influence of materialistic attitudes, we measured materialism using the Material Values Scale³⁹.

Similar to the main study, the independent sample also completed a series of self-reported questionnaires, including the 20-item Positive and Negative Affect Schedule⁴⁰ and Satisfaction With Life Scale³⁷, along with demographic factors including age, sex, education, and subjective socioeconomic status³⁸. We used PA and NA scores of Positive and Negative Affect Schedule⁴⁰ for this sample to measure the affective component of SWB.

Similarity to 'money' or 'friend' using Word2vec

To quantify the semantic similarity between the generated concepts and the target concept (i.e., 'friend' or 'money'), we initially projected each concept onto a 300-dimensional vector using Word2vec¹⁰. These vectors were extracted from pre-trained vectors trained on part of the Google News dataset, with stopwords such as "a," "an," "the," "in," "as," and others removed. For short phrases consisting of multiple concepts, we calculated the vector for each concept individually and then used the average of these vectors. After obtaining a 300-dimensional vector for each word or phrase, we calculated cosine similarity⁴¹, which measures the similarity between two vectors based on the cosine of the angle between them. The similarity ranges from -1 to 1, where 1 indicates perfect similarity, 0 indicates no similarity, and -1 indicates complete dissimilarity. Specifically, we calculated the cosine similarity between 30 individual concepts generated for each seed word and the target concept of 'money' or 'friend,' separately, resulting in six cosine similarities (i.e., cosine similarity to 'friend' or 'money' when the seed was "friend," "money," and "key"; $2 \times 3 = 6$, for our main sample; when the seed was "tear," "family," and "mirror"; $2 \times 3 = 6$, for the independent sample). We then averaged these similarities to obtain an overall cosine similarity score for 'friend' and 'money,' which served as our main variables.

We further calculated Word Mover's Distance (WMD)⁴² which quantifies the minimum semantic distance between two documents or sets of words by considering the movement of words from one document to another. Shorter distances indicate higher similarity between the two documents, while longer distances suggest lower similarity. Specifically, we computed the WMD between the 30 concepts for each seed word and 'friend' or 'money,' resulting in six WMDs (i.e., WMD to 'friend' or 'money' when the seed was "key," "money," and "friend"; $2 \times 3 = 6$, for our main sample; when the seed was "tear," "family," and "mirror"; $2 \times 3 = 6$, for the

independent sample). Subsequently, these WMDs were averaged to derive an overall distance measure for 'friend' and 'money.' Both cosine similarity and WMD are widely utilized across natural language processing research and are known as robust metrics for assessing semantic similarity that leverage word embeddings^{41,42}.

Convergence to 'money' or 'friend' using cosine similarity

To quantify the temporal flows of conceptual associations, we calculated a convergence score based on the trial-by-trial cosine similarity between individual concepts and 'friend' or 'money' for each seed word. In particular, we derived smoothed similarity functions tailored to each participant, capturing the evolving trend of convergence over time. From these functions, six regression slopes and intercepts were obtained per seed word, where the slopes represented the degree of convergence to 'friend' or 'money' and the intercepts indicated the similarity score of the first trial. Subsequently, we averaged the slope values to obtain an overall measure of convergence to 'friend' or 'money.' The intercepts were included as covariates to control for the effects of baseline similarity for each participant.

Statistical analysis

To explore the relationships between SWB, including PA, NA, and LS, and the generated thoughts, we conducted multiple regression analyses. First, we tested regression models with SWB as a predictor and the FAST variables—cosine similarity to, WMD from, convergence to 'friend' or 'money,' and evaluation ratings of valence, importance, and other-self relevance—as outcome variables. Second, to examine the unique contributions of PA, NA, and LS, we included all three variables together as predictors in a single model with the same FAST variables and evaluation ratings as outcomes. Third, to examine whether conceptual associations of the generated thought contents predict choices for social relationships vs. monetary gains, we conducted multiple regression analyses with cosine similarity, WMD, or convergence to 'friend' or 'money' as a predictor and the percentage of salary increase as the outcome variable. In all regression models, age, sex, education, subjective socioeconomic status, and materialism were included as covariates (for the independent sample, age, sex, education, and subjective socioeconomic status were available). For models involving convergence to "friend" or "money," the intercept was additionally controlled. Then, to evaluate the predictive performance of the multiple regression models, we conducted a leave-one-out cross-validation (LOOCV) analysis and compared the mean squared errors (MSEs) with those from the regression analyses using the full data set. This procedure was implemented to assess the generalizability of the models and to reduce bias in model evaluation, given the relatively large number of predictors and the modest sample size. Additionally, we examined the distribution of cosine similarity to, WMD from, and convergence to 'friend' or 'money,' and assessed the variances of these measures using Levene's test for homogeneity of variances. Data distribution was assumed to be normal, but this was not formally tested. Lastly, we conducted a mediation analysis using the PROCESS macro⁴³ with 5000 bootstrap samples to examine whether the conceptual associations mediate the association between SWB and the values placed on social relationships vs. monetary gains. For multiple comparison correction for different seed words, we applied the false discovery rate criterion proposed by Benjamini and Hochberg⁴⁴. Data were analyzed using Python (version 3.11) and IBM SPSS (version 25).

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Results

Conceptual associations of individuals with higher SWB are more similar to 'friend'

We first examined whether SWB, including PA, NA, and LS, is associated with the similarity (i.e., cosine similarity and WMD) of participants' generated thoughts to the target concepts (i.e., 'friend' and 'money'). Note that

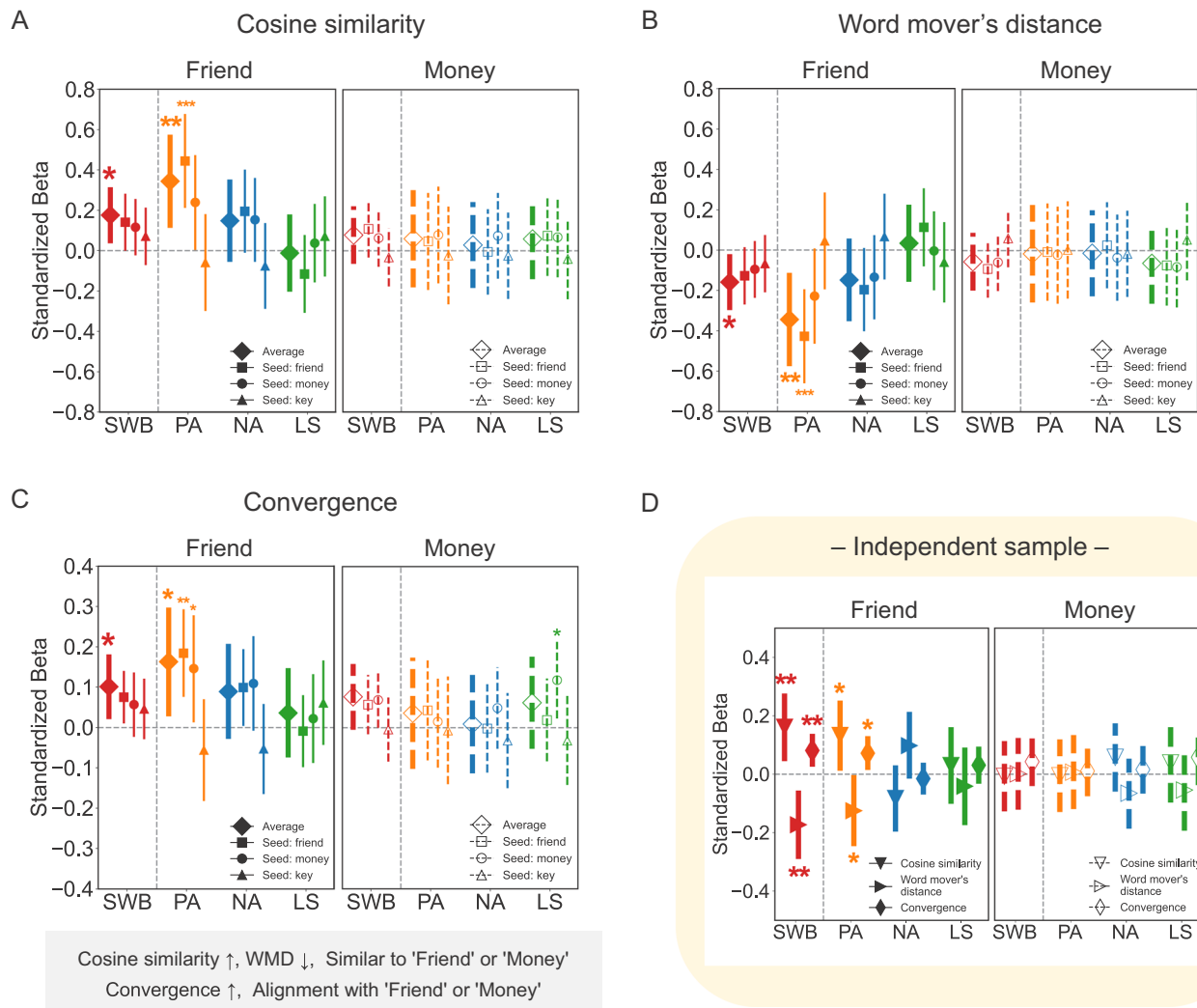


Fig. 2 | The relationships between SWB and similarity/convergence to 'friend' or 'money'. Higher cosine similarity and lower WMD or higher convergence indicate greater semantic similarity to or greater alignment with a target concept (i.e., 'friend' or 'money'). The average scores, as our main variables, represent the mean similarity or alignment of the generated concepts to 'friend' or 'money', regardless of seed words. For exploratory purposes, we also measured cosine similarity, WMD, and convergence for each seed word. Overall, participants with higher SWB, particularly those with greater PA, generated concepts with higher cosine similarity to 'friend' and lower WMD from 'friend,' but not to 'money,' as shown in (A) for cosine similarity and (B) for WMD, respectively. C Participants with higher SWB, especially PA, increasingly generated concepts similar to 'friend' over time. D We

conducted the identical analyses with the independent sample and observed patterns similar to those in our main sample. Specifically, the concepts generated by participants with greater SWB had overall higher cosine similarity to and lower WMD from 'friend,' and they generated concepts similar to 'friend' as the trials progressed. The effect of PA was also evident, as shown in our main sample. The detailed results are presented in Supplementary Table S3 through S8. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. For different seed words, adjusted p values were applied. Error bars indicate 95% confidence intervals. Panels A–C are based on the US/UK sample ($n = 210$), and Panel D is based on the South Korea sample ($n = 330$; SWB data available for 330 of 350 participants).

the variable of our major interest is the average similarity scores that reflect the overall similarity regardless of the seed words, while we additionally report the results for the similarity scores separately calculated for different seed words (Fig. 2A–C).

In line with our expectation, participants with greater SWB generated concepts with higher cosine similarity to 'friend' ($\beta = 0.176$, $t_{203} = 2.505$, $p = 0.013$, 95% confidence interval, CI = 0.037 to 0.314; Fig. 2A). A multiple regression analysis with PA, NA, and LS as predictors and the average cosine similarity to 'friend' as an outcome variable showed that only PA was significantly correlated with the cosine similarity. Overall, the concepts generated by participants with greater PA exhibited higher similarity to 'friend' ($\beta = 0.344$, $t_{201} = 2.942$, $p = 0.004$, 95% CI = 0.113 to 0.574; Fig. 2A). Additional analyses of the cosine similarity score for each seed word revealed a consistent positive relationship between PA and the cosine similarity to 'friend' when the seed word was "friend" ($\beta = 0.444$, $t_{201} = 3.767$, $p < 0.001$, 95% CI = 0.212 to 0.677; Fig. 2A). We did not detect a

significant association between cosine similarity to 'money' and any of the SWB measures (Fig. 2A). Detailed results related to the cosine similarity are shown in Supplementary Tables S3-1 and S3-2.

The analyses on the WMD from the target concepts (i.e., 'friend' or 'money') yielded consistent results. Participants with greater SWB generated concepts with shorter average WMD from 'friend,' in other words, closer to 'friend' ($\beta = -0.158$, $t_{203} = -2.252$, $p = 0.025$, 95% CI = -0.297 to -0.020; Fig. 2B). A multiple regression analysis with PA, NA, and LS as predictors and the average WMD score as an outcome variable revealed that greater PA was significantly associated with a shorter distance from 'friend' ($\beta = -0.344$, $t_{201} = -2.935$, $p = 0.004$, 95% CI = -0.575 to -0.113; Fig. 2B). A similar pattern was observed when we analyzed the WMD calculated for the concepts generated from the seed word "friend" ($\beta = -0.427$, $t_{201} = -3.610$, $p < 0.001$, 95% CI = -0.660 to -0.194; Fig. 2B). We found no significant association between any of the SWB measures and the WMD from 'money' (Fig. 2B). Unlike PA, neither NA nor LS was associated with the cosine

similarity or the WMD (Fig. 2B). Detailed results related to the WMD are shown in Supplementary Tables S4-1 and S4-2.

To explore whether the observed pattern would also emerge in a different cultural context, we analyzed an independent sample of Korean participants. Consistent with the findings from our main sample of US/UK participants, we found that the concepts generated by participants with greater SWB had higher cosine similarity to 'friend' ($\beta = 0.161$, $t_{324} = 2.726$, $p = 0.007$, 95% CI = 0.045 to 0.276), whereas cosine similarity to 'money' showed no significant correlation with SWB ($\beta = -0.007$, $t_{324} = -0.115$, $p = 0.909$, 95% CI = -0.127 to 0.113). A multiple regression analysis with PA, NA, and LS as predictors further revealed that PA was positively associated with similarity to 'friend' ($\beta = 0.133$, $t_{322} = 2.169$, $p = 0.031$, 95% CI = 0.012 to 0.252). Analyses on the WMD measures with the independent sample showed the same patterns. Participants with greater SWB generated concepts with shorter distances from 'friend' ($\beta = -0.173$, $t_{324} = -2.910$, $p = 0.004$, 95% CI = -0.290 to -0.056). In the multiple regression analysis with PA, NA, and LS, greater PA significantly predicted a shorter distance from 'friend' ($\beta = -0.125$, $t_{322} = -2.021$, $p = 0.044$, 95% CI = -0.246 to -0.003). Again, no significant correlations with any of the SWB measures were found for similarity to 'money'. Neither NA nor LS was correlated with the cosine similarity or the WMD in the independent sample, consistently suggesting the specific involvement of PA in the similarity of the generated thoughts to 'friend'. Detailed results related to cosine similarity and WMD of the independent sample are shown in Supplementary Tables S5 and S6, respectively.

Conceptual associations of individuals with higher SWB are more likely to converge to 'friend'

We further examined whether the happier participants' conceptual associations are more inclined to converge to 'friend' or 'money'. The convergence score was calculated for each individual based on a linear regression slope of trial-by-trial cosine similarity values interpolated from the first trial to the last trial (see Methods for details). The greater convergence score indicates an increasing trend in the similarity score toward a target concept. The results showed that participants with greater SWB exhibited greater convergence to 'friend' ($\beta = 0.101$, $t_{202} = 2.492$, $p = 0.014$, 95% CI = 0.021 to 0.181; Fig. 2C). A multiple regression analysis with PA, NA, and LS as predictors revealed that PA was significantly associated with the convergence to 'friend' ($\beta = 0.163$, $t_{200} = 2.389$, $p = 0.018$, 95% CI = 0.028 to 0.297; Fig. 2C). Further analyses with the convergence score separately calculated for each seed word revealed that PA was positively correlated with the convergence to 'friend' when the seed word was "friend" ($\beta = 0.184$, $t_{200} = 3.358$, $p = 0.003$, 95% CI = 0.076 to 0.293; Fig. 2C). PA showed a significant positive association with the convergence to 'friend' even when the seed word was "money" ($\beta = 0.146$, $t_{200} = 2.165$, $p = 0.048$, 95% CI = 0.013 to 0.278; Fig. 2C). None of the convergence scores to 'money' were related to SWB, PA, or NA, but we unexpectedly found a significant association between LS and the convergence to 'money' when the seed word was "money" ($\beta = 0.118$, $t_{200} = 2.440$, $p = 0.048$, 95% CI = 0.023 to 0.213; Fig. 2C). Detailed results related to the convergence are shown in Supplementary Tables S7-1 and S7-2.

We again performed the identical analyses with the independent sample of Korean participants and found consistent results (see Fig. 2D for all summarized results of the cosine similarity, WMD, and convergence). Participants with higher SWB showed greater tendency to align their conceptual associations with 'friend' as the trials progressed ($\beta = 0.081$, $t_{323} = 2.889$, $p = 0.004$, 95% CI = 0.026 to 0.138). This effect was only observed for PA ($\beta = 0.072$, $t_{321} = 2.487$, $p = 0.013$, 95% CI = 0.015 to 0.130) in the multiple regression analysis with PA, NA, and LS as predictors. Detailed results related to the convergence of the independent sample are shown in Supplementary Tables S8-1 and S8-2.

Evaluations of the generated concepts vary with SWB

Next, we examined how SWB is linked to the evaluations of participants' generated concepts. Overall, we found that higher SWB was associated with more positive evaluations ($\beta = 0.358$, $t_{203} = 5.332$, $p < 0.001$, 95% CI = 0.226 to 0.491; Fig. 3A) and greater perceived relevance to others than to oneself

($\beta = 0.237$, $t_{203} = 3.354$, $p = 0.001$, 95% CI = 0.097 to 0.376; Fig. 3A), irrespective of the seed words. Fig. 3B illustrates this relationship with word cloud examples of the generated concepts from four representative participants with varying levels of SWB. Then, we performed multiple regression analyses on the effects of PA, NA, and LS on the valence, importance, and other- vs. self-relevance ratings. The results showed that PA was significantly correlated with the valence rating ($\beta = 0.262$, $t_{201} = 2.315$, $p = 0.022$, 95% CI = 0.039 to 0.485; Fig. 3A) such that participants with greater PA evaluated the generated concepts more positively. The multiple regression analysis on the other- vs. self-relevance ratings revealed that participants with greater NA were more likely to evaluate the generated concepts as more relevant to self than others ($\beta = -0.251$, $t_{201} = -2.398$, $p = 0.017$, 95% CI = -0.458 to -0.045; Fig. 3A).

In further exploration of the evaluation scores of the generated concepts from different seed words, we found that PA was significantly linked to more positive assessments of the generated concepts when the seed word was "friend" ($\beta = 0.387$, $t_{201} = 3.365$, $p = 0.003$, 95% CI = 0.160 to 0.613; Fig. 3A), while we did not find significant associations of NA and LS with the valence rating. For the other- vs. self-relevance rating, the effect of NA was significant when the seed words were "money" ($\beta = -0.249$, $t_{201} = -2.381$, $p = 0.027$, 95% CI = -0.456 to -0.043; Fig. 3A) and "key" ($\beta = -0.307$, $t_{201} = -2.973$, $p = 0.009$, 95% CI = -0.510 to -0.103; Fig. 3A), while no significant effects were found for PA or LS. We did not observe a significant association between importance ratings and any of the SWB measures (Fig. 3A). Detailed results related to the evaluation scores are shown in Supplementary Tables S9-1 and S9-2.

Conceptual associations with 'friend' predict individuals' prioritization of social relationships over monetary gain

To examine whether the conceptual associations could predict individuals' choices, we presented a realistic dilemma in which the values of social relationships and monetary gains conflict. In this scenario, participants were asked to indicate the degree of income increase that would make them willing to accept a lucrative job offer at the cost of sacrificing their close relationships. The data showed that participants who generated concepts similar to 'friend' responded that they would need a greater income increase, in other words, placed greater value on social relationships. Specifically, this preference for social relationships over monetary gains was correlated with greater cosine similarity to 'friend' ($\beta = 0.176$, $t_{185} = 2.399$, $p = 0.017$, 95% CI = 0.031 to 0.315; Fig. 4A) and shorter WMD from 'friend' ($\beta = -0.183$, $t_{185} = -2.497$, $p = 0.013$, 95% CI = -0.321 to -0.038; Fig. 4A). Interestingly, this pattern was especially evident for the seed word "money," where the cosine similarity to 'friend' showed a significant influence ($\beta = 0.193$, $t_{185} = 2.648$, $p = 0.027$, 95% CI = 0.048 to 0.327; Fig. 4A), when we analyzed the similarity measures calculated separately for different seeds. A marginal effect was also observed with WMD from 'friend' for the seed word "money" ($\beta = -0.173$, $t_{185} = -2.367$, $p = 0.057$, 95% CI = -0.309 to -0.028; Fig. 4A), when analyzing the similarity measures for different seeds. Detailed results related to the dilemma task are shown in Supplementary Tables S10-1 to S10-3.

To ensure the predictive power of our analyses, we also performed LOOCV analysis. When we compared the MSEs from the LOOCV with those from our initial regression analyses using the full dataset to evaluate the predictive performance of our regression models, none of the MSEs from the full dataset significantly deviated from the individual MSEs or exceeded one standard deviation from the average MSEs, lending support to the validity of our models (Fig. 4B and Supplementary Table S10-4).

Finally, we examined whether the effects of SWB on participants' prioritization of social relationships over monetary gains were mediated by their conceptual associations. We found that those with higher SWB prioritized social relationships over monetary gains, and this relationship was mediated by the overall greater similarity of the generated concepts to 'friend' (indirect effect of cosine similarity: $\beta = 0.025$, $SE = 0.016$, 95% CI = 0.002 to 0.076, Fig. 4C; indirect effect of WMD, $\beta = 0.024$, $SE = 0.015$, 95% CI = 0.001 to 0.073, Supplementary Fig. S1A). When analyzing PA,

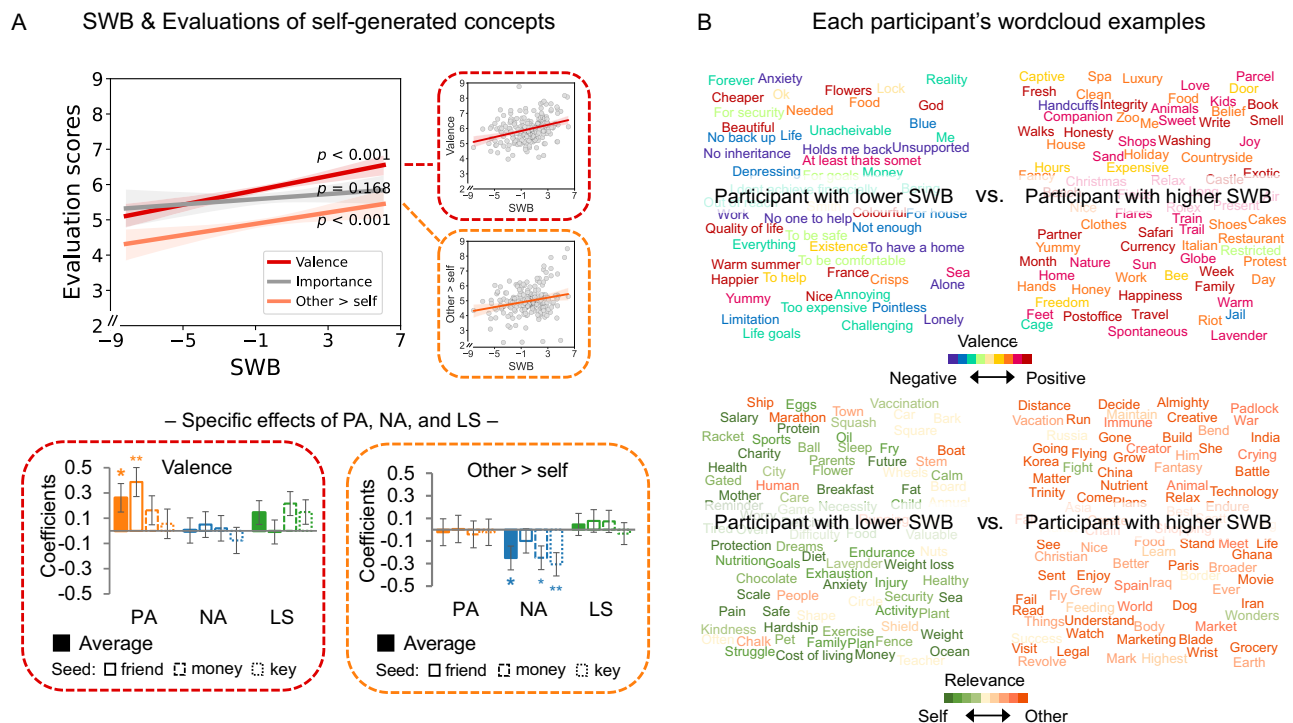


Fig. 3 | Evaluations of the generated concepts and word cloud examples from four participants. **A** Individuals with higher SWB rated the generated concepts more positively and perceived them as more relevant to others than themselves, regardless of the seed words used. When analyzing the specific effects of PA, NA, and LS, greater PA was associated with more positive evaluations of the concepts, while greater NA was associated with greater perceived relevance of the concepts to

oneself than to others. The detailed results are presented in Supplementary Table S9. Error bars indicate ± 1 standard error of the mean. Panel (A) is based on the US/UK sample ($n = 210$). **B** Word cloud examples from those with higher and lower SWB display the 90 reported concepts, with color coding reflecting the valence scores (above) and the scores of other- vs. self-relevance (below) for each concept. $*p < 0.05$, $**p < 0.01$. For different seed words, adjusted p values were applied.

NA, and LS separately, the same mediational results were observed when PA was entered into the model as the predictor (indirect effect of cosine similarity: $\beta = 0.033$, $SE = 0.019$, 95% CI = 0.001 to 0.054; indirect effect of WMD, $\beta = 0.033$, $SE = 0.018$, 95% CI = 0.003 to 0.053; Supplementary Fig. S1B). For results of NA and LS, see Supplementary Fig. S1C and S1D.

Discussion

The present study explored the relationship between spontaneous thoughts and happiness using a combination of the free association paradigm and natural language approach. We systematically assessed and interpreted the contents of participants' generated thoughts and found that thoughts related to 'friend' were positively associated with SWB, an effect largely accounted for by PA. These relationship-relevant thoughts predicted decisions favoring social relationships over monetary gains, suggesting a behavioral mechanism through which spontaneous thoughts can influence an individual's happiness.

Consistent with previous evidence indicating that happier individuals are often characterized by positive relationships and abundant social resources^{12,13,19}, we found that individuals with higher SWB tended to generate concepts that were more closely related to 'friend.' This pattern was observed across all of our semantic similarity measures, including cosine similarity, WMD, and convergence scores, and this pattern held regardless of the presentation order of seed words (see Table S11). Notably, the consistent relationship between SWB and conceptual associations with 'friend' was corroborated and extended in an independent sample of Korean participants, who speak a different language and come from a distinct cultural background.

The effect of PA, among the subcomponents of SWB, on conceptual associations with 'friend' was particularly pronounced. This result aligns with prior research demonstrating a robust and reciprocal link between PA and positive social relationships^{45–47}. The broaden-and-build theory suggests that PA not only strengthens social connections but also initiates a virtuous

cycle in which rich social resources amplify positive emotional states⁴⁸. The prevalence of friend-related thoughts among individuals with greater PA seems to reflect this bidirectional relationship. Interestingly, the convergence of thoughts toward 'friend' persisted even when the seed word was "money." This suggests that, for those with greater PA, social aspects may be broadly embedded within their semantic networks, extending to other domains. For example, individuals with greater PA may evoke thoughts of sharing positive experiences with others even in contexts related to material resources⁴⁹. By contrast, the effects of LS and NA on conceptual associations with 'friend' were less robust than that of PA, although the overall effect of SWB was significant. This is consistent with the idea that the sub-components of SWB have both common and component-specific sources⁵⁰: LS, as a global evaluation of one's life³⁷, may be less likely to be captured by temporarily activated conceptual associations, while NA may be more closely related to its own sources, distinct from those of PA, such as stressors across multiple domains (e.g., relationships, work, health, and finances)⁵¹, which could weaken its association with 'friend.' Taken together, these findings not only confirm the well-established link between SWB, particularly PA, and social relationships, but also enrich our understanding of how the value of social relationships is semantically represented within the thoughts of individuals reporting higher happiness.

Building on the positive association between SWB and friend-related thoughts, we examined whether individual differences in thought content are associated with decision preferences and potentially contribute to happiness. Importantly, participants' friend-related thoughts predicted their choices between social relationships and monetary gains in a realistic dilemma task, which they completed a few days after the FAST session. Our mediation analysis further revealed that happier participants were more likely to prioritize social relationships over monetary gains, with friend-related thoughts mediating this relationship. Previous research has shown that individuals with higher SWB tend to prefer social gains over financial or academic ones, utilizing positive social relationships as a buffer against

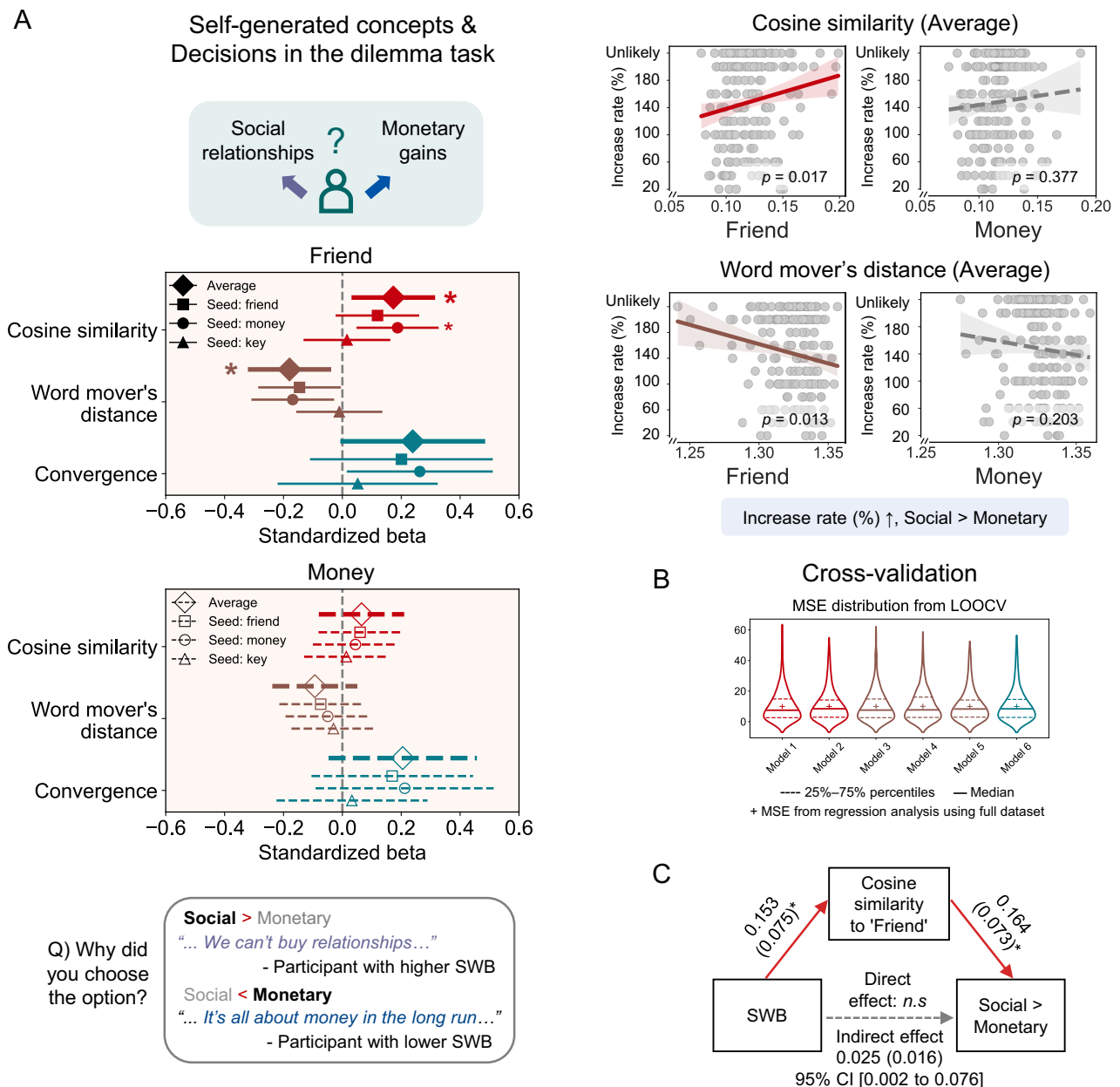


Fig. 4 | Similarity and convergence to ‘friend’ or ‘money’ and choices between social relationships and monetary gains in the dilemma task. **A** Overall, participants who generated concepts similar to ‘friend’ in the FAST tended to prioritize social relationships over monetary gains. Error bars indicate 95% confidence intervals. **B** We compared the MSEs from LOOCV with those from our initial regression analyses using the full dataset to evaluate the predictive performance of our regression models. None of the MSEs from the full dataset significantly deviated from individual MSEs or exceeded one standard deviation from the average MSEs from LOOCV, lending support to the validity of our models. The model number, in sequence, represents the results when cosine similarity (average and seed word

“money”) to, WMD (average, seed word “friend,” and seed word “money”) from, and convergence (seed word “money”) to ‘friend’ were entered as predictors. For a more comprehensive analysis, we included the results with uncorrected $p < 0.05$, as well as those shown in Fig. 4A. The detailed results are presented in Supplementary Table S10. **C** Participants with higher SWB prioritized social relationships over monetary gains, and this relationship was mediated by the overall greater similarity of the generated concepts to ‘friend’ (See Supplementary Fig. S1A for the results of the indirect effect of WMD from ‘friend’). Standardized path coefficients are shown, with standard errors in parentheses. * $p < 0.05$. For different seed words, adjusted p values were applied. Panels A–C are based on the US/UK sample ($n = 192$).

negative experiences, leading to better hedonic outcomes in both laboratory and everyday contexts^{29,30,52}. Our findings bridge the gap between happiness and preference by demonstrating that the moment-to-moment stream of thoughts can influence individuals’ choices. Given the benefits of positive social relationships^{53–56}, the different choices made by happy and unhappy individuals, guided by distinct semantic landscapes, may accumulate over time, leading to divergent outcomes and serving as a behavioral mechanism through which spontaneous thoughts contribute to happiness.

Interestingly, we did not find statistically significant associations between money-related thoughts and SWB on most of the semantic

measures, as predicted from the inconsistent findings in previous research^{20,21,25}. The only significant result was the positive correlation between LS and the convergence toward ‘money’ when the seed word was “money.” This is consistent with previous findings suggesting that wealth is more relevant to cognitive than affective aspects of happiness. Such a pattern further underscores that different SWB components map onto distinct domains: whereas PA was closely tied to friend-related thoughts, LS was related to money-related concepts, albeit in a limited way. This may arise because money is a secondary reinforcer, gaining its value via learned associations with a primary reinforcer⁵⁷, unlike the inherently rewarding

nature of social interactions¹⁸. Thus, the connection between happiness and money-related thoughts may be relatively limited. Another possible reason for this disparity is the smaller variance in thoughts about ‘money’ across individuals compared to ‘friend.’ In our data, variance in friend-related thoughts across individuals was more pronounced than that in money-related thoughts across most variables (see Supplementary Fig. S2). This pattern may imply that social relationships occupy a more divergent and personalized space in individuals’ minds than monetary ones, a possibility that merits further investigation in the future.

It is noteworthy that in both cultural samples, higher SWB was associated with greater conceptual associations with “friend.” However, participants in the US/UK sample showed stronger associations with money-related concepts than those in the Korean sample (Table S12). While cultural orientations such as individualism emphasize autonomy⁵⁸ and may heighten the salience of financial concerns, this pattern may also reflect age-related factors as the Korean sample was in their early twenties whereas the US/UK sample was in their late twenties. For instance, the value of financial independence, which typically becomes more prominent in late twenties⁵⁹, may increase the salience of monetary concepts. Future research should examine cultural influences on the relative importance of interpersonal versus monetary domains.

Subjective ratings of the generated concepts further reveal distinctive features of thoughts that occupy happier minds: positive thoughts about others. First, we found that participants with higher SWB and PA evaluated their generated concepts more positively. This result does not appear to stem from a general positivity bias among happier participants, as overall valence scores were correlated with semantic similarity measures of friend-related thoughts (cosine similarity to ‘friend’: $r_{210} = 0.185$, $p = 0.007$, 95% CI = 0.051 to 0.313; WMD from ‘friend’: $r_{210} = -0.149$, $p = 0.030$, 95% CI = -0.279 to -0.014) but not with those of money-related thoughts (cosine similarity to ‘money’: $r_{210} = 0.096$, $p = 0.167$, 95% CI = -0.040 to 0.228; WMD from ‘money’: $r_{210} = -0.037$, $p = 0.597$, 95% CI = -0.171 to 0.099). Second, participants with higher SWB and lower NA rated the concepts as more other-relevant than self-relevant. This finding is particularly intriguing given the well-known association between other-oriented behaviors and happiness^{60–62}. Extended engagement with or interest in others, as reflected in individuals’ semantic networks, might serve as a foundation for strengthening social connections, thereby enhancing SWB. Conversely, greater NA seems to be associated with more self-focused thoughts, aligning with evidence suggesting that it narrows one’s attention to personal needs and fosters a more inward-oriented thought process⁶³. In our data, higher cosine similarity to ‘money’ was correlated with lower other- versus self-relevance ratings. This suggests that money-related thoughts are more self-centered, which may partially explain the less pronounced relationship between money-related thoughts and SWB measures.

Limitations

The limitations of the present study should be addressed. First, although our dataset exceeded the required sample size and included participants from two cultural backgrounds, it lacked demographic diversity in age, ethnicity, socioeconomic status, and nationality. Most participants in the main sample were in their late twenties, while those in the independent sample were college students. This life stage may have heightened the salience of interpersonal relationships over financial concerns, potentially contributing to stronger associations of SWB with ‘friend’ than with ‘money.’ Second, while “friend” is a meaningful concept for capturing interpersonal relationships, it may not fully represent the diversity of close relational experiences, such as those involving family or romantic partners. This limitation is particularly relevant in contexts where other types of close relationships or social ties may hold greater personal or cultural significance. Third, because the FAST involves deliberate responses within an experimental setting rather than capturing spontaneous thought directly, future research would benefit from more naturalistic measures. Lastly, as the observed association with SWB was primarily driven by positive affect, broader interpretations should be made with caution. Studies with larger and demographically varied samples

will help clarify how the value of social relationships is reflected in spontaneous thought and everyday decision-making.

Conclusions

Overall, the present study advances understanding of how conceptual association relate to happiness. Our findings suggest that greater happiness is associated with thought patterns more closely tied to interpersonal relationships, and this tendency influences their decisions to prioritize social values over monetary ones. The positive and other-relevant nature of happy individuals’ generated thoughts highlights the roles of emotional valence and (pro-)sociality in happiness. By capturing specific semantic features related to happiness, our work holds theoretical importance in understanding how the value of social relationships is reflected in individuals’ minds and behaviors, potentially contributing to happiness.

Data availability

The data are shared at <https://osf.io/un3jk/>.

Code availability

The code for analyses are shared at <https://osf.io/un3jk/>.

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Author contributions

Won-Gyo Shin: Conceptualization, Formal analysis, Funding Acquisition, Investigation, Methodology, Visualization, Writing; Jeongyeol Ahn: Methodology, Software; Kyoung Whan Choe: Methodology, Software; Hyeeseung Lee: Methodology, Software; Jihoon Han: Resources; Eunjin Lee: Resources; Byeol Kim Lux: Resources; Choong-Wan Woo: Funding Acquisition, Methodology, Resources; Incheol Choi: Conceptualization, Funding Acquisition, Supervision; Sunhae Sul: Conceptualization, Funding Acquisition, Methodology, Supervision, Writing.

Competing interests

The authors declare no competing interests.

Additional information

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