



Research article

Does anime, idol culture bring depression? Structural analysis and deep learning on subcultural identity and various psychological outcomes

Yinghao Liu ^{a,*}, Yingxu Liu ^{b,1}, Jiahao Wen ^c^a Faculty of Arts and Letters, Department of Behavioral Science, Tohoku University, Japan^b Department of Aging Research and Geriatric Medicine Institute of Development, Aging and Cancer, Tohoku University, Japan^c Graduate School of Information Sciences, Tohoku University, Japan

HIGHLIGHTS

- Identity related to anime, idol, and hip-hop was positively associated with adverse psychological outcomes.
- Identity related to fashion and sports had no association with positive or adverse psychological outcomes.
- Perceived reputation mediates adverse psychological outcomes.
- Neural network can predict psychological problems based on cultural preference.

ARTICLE INFO

Keywords:

Subculture
Social support
Reputation
Psychological outcomes
Neural networks

ABSTRACT

Subculture, includes animation, comics, games (ACG), and idol fan culture, is popular among young generations in Japan. Previous studies have shown different psychological outcomes within different subcultural groups; however, underlying mechanisms remain unclear. This study proposes that subcultural identity may play a crucial role in mental health outcomes by interweaving social support and reputation. We examined the interplay between subcultural identity, social support, reputation, and different psychological outcomes through structural equation modeling (N = 300). Furthermore, we trained neural networks (NN) by applying a deep learning algorithm to predict psychological outcomes of different subcultures. The results suggest identity related to anime, idol, and hip-hop was positively associated with anxiety, aggression, depressive symptoms, and suicidal tendencies. By contrast, fashion and sports identities associated with no adverse or positive psychological outcomes. Perceived reputation mediates adverse psychological outcomes in the ACG, idol, and hip-hop groups. The highest accuracy in our NN reached 71%, indicating that NN could be an effective tool for predicting mental problems. Our work points up an urgent need to improve the mental health of the young generation by de-stigmatizing discriminated cultural groups.

1. Introduction

Subcultural, in opposition to dominant culture, such as animation, comics, and games (ACG), and fan culture, is prevalent among young adults in Japan (Chandler-Olcott and Mahar, 2003). Researchers have discovered the importance of subculture-related activities in producing common identification and providing social support, thereby generating a significant impact on attitudes and behaviors (Horowitz and Vigil, 1990; Shildrick and MacDonald, 2006). Also, subcultural elements help to build group identity and reputation for youths in Japan (Ishii, 2014).

Effective support from cultural activities (i.e., singing, playing an instrument, or painting) decreases anxiety and other adverse psychological outcomes (Cuypers et al., 2012). Similarly, subcultural enthusiasm generates various clinical symptoms; for example, goths were discovered to have a tendency toward depression and self-harm (Bowes et al., 2015). By contrast, sports encourage better health situations (Wann and Stephanie, 2005).

Subcultures may have a unique mechanism of mental health outcomes by interweaving social support and reputation. Therefore, this study clarifies the interplay between various subcultures, social support,

* Corresponding author.

E-mail address: liu.yinghao.r8@dc.tohoku.ac.jp (Y. Liu).¹ Yinghao Liu and Yingxu Liu contribute equally to this work.

reputation and psychological outcomes, including depressive symptoms, anxiety, hostility, aggression, suicidal ideation, and empathy concerns. Our theoretical model is presented in [Figure 1](#).

1.1. Subculture identity and various psychological outcomes

Subcultural identity is based on the identification of specific ethics, music, dress codes, and other cultural elements ([Shildrick and MacDonald, 2006](#)). Our research focused on the influence of youth subcultural identity on psychological outcomes. Specifically, identities related to anime, idol fandom, hip-hop, fashion, and sports are taken into consideration.

The reason we choose anime, idol culture is that although they comprise large proportion of youth entertainment in Japan, they commonly relate to stigmas such as “Dasai” or “Otaku” (Dasai refers to an out-of-fashion, unattractive appearance; Otaku describes people who are homebodies) and induce school-related problems like non-attendance, or isolation ([Leshner et al., 2018](#)). Hip-hop, however, is a newly-controversial topic, with some endorsing its rebellious spirit while others relate it to youth delinquency ([Crooke et al., 2020](#); [Robinson et al., 2018](#); [Ter Bogt et al., 2013](#)). By contrast, sporty and fashionable characters are endorsed among youth ([Ishii, 2014](#)).

More importantly, empirical studies have highlighted different subcultures result in different psychological outcomes. [Bowes et al. \(2015\)](#) found that goth identity followed the risk of depression and self-harm. Anime or idol fans perceive serious discrimination, which could induce depressive symptom ([Leshner et al., 2018, 2020](#)). In contrast, sports fan identity is associated with better psychological wellbeing ([Wann and Stephanie, 2005](#)). Belonging to each subculture group may underpin one’s social fame and network in a common or specific way, suggesting the linkage involving subcultural identity and ultimate psychological status, especially among the young generation.

1.2. Subculture identity and social support

Common identity provides the basis for exchanging social support ([McNamara et al., 2021](#); [Shildrick and MacDonald, 2006](#)). Study shows that, a person’s willingness to help a stranger in distress is enhanced when the stranger is perceived to share a relevant social identity with the helper ([Levine et al., 2005](#)). For usually-adverse subculture groups, easily exposed to injustice, the perception of sharing common identity with another forms the basis for exchanging resource and emotional support to tackle daily difficulties ([Haslam et al., 2005](#)).

According to [Cobb’s \(1976\)](#) definition, social support refers to being cared for, respected, and valued. Research on sports fans shows that the

common identity and fan relationship is highly valued, which builds strong social support within the group ([Wann and Stephanie, 2005](#)). However, the anime or idol fan group, which possesses a lower self and group evaluation ([Leshner et al., 2018](#)), could result in ineffective social support.

1.3. The reputation of subculture groups

According to socioanalytic theory, social identity and reputation are crucial interrelated components to define one’s personality ([Gottlieb et al., 2021](#); [Hogan, 1983](#)). Identity denotes how actors see themselves, which is personal narrative, while reputation denotes how an actor believes that others will perceive them, which established by social observation. Reputation and self-identification accounts for the individual differences in personality, attitudes, competent performance and mental status ([Gottlieb and Göttsche-Astrup, 2020](#); [Wihler et al., 2017](#)). Among youths, subcultural identity may influence their percept on reputation, which is reflected as psychological differences.

Studies on online Ana groups have revealed that rebuilding reputation is the central activity within group. The Ana group is an online community that encourages young people to obtain super-slim bodies through fasting or vomiting and affirms anorexia and bulimia as legitimate lifestyles. As this unhealthy lifestyle will not receive positive recognition and support from outside society, within such groups, members tend to justify their lifestyle by stating, ‘Starvation is the most fun a girl can have’ ([Crowe and Hoskins, 2019](#); [Gailey, 2009](#)).

Also, a Japanese high school study showed that reputation is important among peers. Among high school peers, groups are divided and ranked according to subcultural elements ([Ishii, 2014](#)). Groups possessing characteristics such as sporty and fashionable enjoy a higher reputation. However, students with less attractive appearances, or enthusiasm for anime face stigma. Studies note that perceived reputation is a robust predictor of mental health problems ([Foster et al., 2021](#)). Similarly, we speculate that youth in lower-reputation groups are linked to various adverse psychological outcomes.

1.4. Hypothesis

Subcultural identity, social support, and reputation are related to loneliness, depression, and anxiety ([Bowes et al., 2015](#); [Leicht-Deobald et al., 2018](#)). However, previous research has concentrated on individual relationships rather than on combining these factors. To understand the mechanism by which subcultural identity, social support, and reputation jointly contribute to youth psychological outcomes, we proposed that:

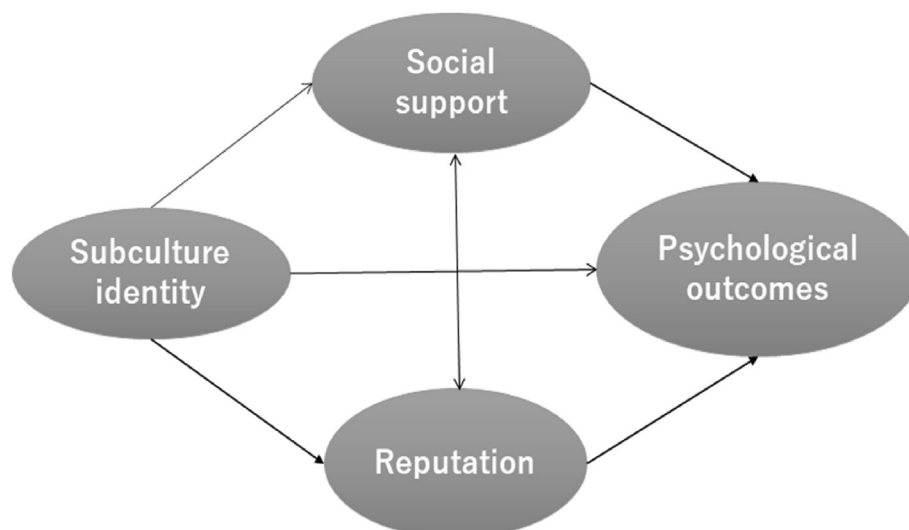


Figure 1. Theoretical model.

H1. Different subcultural identities are associated with various psychological outcomes.

H2. Different subculture identities are associated with various psychological outcomes, and they are mediated by social support.

H3. Different subcultural identities are associated with various psychological outcomes, and they are mediated by reputation.

2. Method

2.1. Sample size and subjects

Depressive symptoms measured by the Beck Depression Inventory were considered as the main outcome and typically have a moderate effect ($f^2 = 0.15$) (Seggar et al., 2002). Using G-power with an error probability of $\alpha = 0.05$ and 0.8 power, we calculated the lowest sample size of 90 to detect a moderate difference. To better control the response quality, we finally enrolled 300 Japanese participants. The target subjects were young adults (average age: 21.3; standard deviation: 4.3 years) without psychological disease. The participants were informed of the study's purpose and provided informed consent. The research was approved by the ethics committee of Tohoku University and compiled between September to December 2021.

2.2. Measurements

2.2.1. Subculture identity

The five categories of subculture "ACG," "idol," "sports," "fashion," and "hip-hop" were included. The social identification measure of Doosje et al. (1995) was adjusted to check for subcultural identity. Participants have to rate on a scale from 1 = 'not at all' to 7 = 'extremely' to questions 'I see myself as a member of the ACG (anime, comic, game)/sports/idol/fashion/hip-hop group'. Participants were allowed to choose a rating identity score under each subculture group.

2.2.2. Social support

Social support was measured using the Japanese version of the Duke Social Support Index (DSSI-J) (Zimet et al., 1988), with high reliability and validity (Cronbach's $\alpha = 0.868$, GFI = 0.916). Twenty-five items were measured on a 5-point Likert scale, with higher scores indicating higher support. Specifically, nine items were used to define emotional support (i.e., Do you listen to by family and friends, can you talk about your deepest problem?); six items were used to define instrumental support (i.e., Do family or friends ever help you shop or run errands for you?) and seven items were used to define perceived support (i.e., Do family and friends ever help you out with money?).

2.2.3. Reputation

To simplify the measurement of reputation, we used two items to assess perceived group and personal reputation brought with subculture identity ("My group is reputable") and personal ("I feel reputable because I belong to this group"). Responses were made on a 7-point Likert-type scale, from 1 = strongly disagree to 7 = strongly agree. A higher value suggests a better reputation.

2.2.4. Outcome measurement

Depressive symptoms were evaluated using the Japanese version of the Beck Depression Inventory-II (BDI-II) (Kojima et al., 2002) with 21 items. The score ranges from 0 to 63, with higher scores indicating more depressive symptoms.

Anxiety was measured using the State-Trait Anxiety Inventory (STAI) with 40 items. Of the 40 items, 20 items measure the recent anxiety state, and 20 items measure anxiety in one's personality. Both range from 20 to 80, with a higher summed score indicating a higher anxiety status (Iwata and Mishima, 2016).

Aggression was measured using the State-Trait Anger Inventory subscales. The state and personal traits of anger were included. In both

domains, scores ranged from 10 to 40, with higher summed scores indicating a more aggressive status (Shimoda and Terasaka, 2012).

Suicidal ideation was measured using the Japanese short version of the suicidal ideation scale with six items; the total range is from 0 to 12, with higher scores indicating higher suicidal trends (Sato et al., 2014).

Empathy was measured using the Japanese version of the Interpersonal Reactivity Index with 28 items that were divided into four subscales: fantasy (FS), personal taking (PT), empathetic concern (EC), and personal distress (PD). The range is from 7 to 35 for each group of sub-items; the higher the sum score, the better the individual's empathetic ability (Xiao and Toyama, 2020).

2.3. Statistical analysis

We aimed to detect multiple associations within different subculture groups across metrics, including social support, reputation, and various psychological outcomes using a two-step approach.

First, we applied the structural equation model (SEM) to test whether subcultural identity, social support, and psychological outcomes were synergistically associated. The maximum likelihood (ML) was used for estimation and testing in SEM. In this method, parameter estimates are obtained by maximizing the likelihood function derived from the multivariate normal distribution. Identity under each subculture group, social support and reputation were inputted as original value. Psychological measurements were inputted with standardized z-score due to large range differences.

As our hypothesis focuses on the difference between subcultural groups, we set ACG, idol, and hip-hop in one group to build one latent subcultural identity and fashion and sports in another. The reason for this separation is that Anime and Idol's culture have consistently suggested unfavorable social fame and were responsible for school-related problems like non-attendance or isolation (Leshner et al., 2018). Recent studies also pointed out that Hip-hop, a newly controversial topic, has related to youth delinquency, violence and health behaviors such as tobacco use (Ter Bogt et al., 2013; Crooke et al., 2020; Robinson et al., 2018). To this end, we combined Anime, Idol, and Hip-pop as 'unfavorable' subculture groups. Whereas Sports and Fashion usually have a favorable trend toward social reputation and physical-mental status among the youth. Therefore, we consider Sports and Fashion have different latent characteristics compared to the 'unfavorable' (Anime, idol and hip-hop) group. For the psychological outcomes, we categorized depression, aggression, and anxiety into adverse psychological outcome group, depression and suicide into the severe adverse psychological outcome group, and empathy into positive psychological outcome group. The reason for this arrangement is that depression, aggression, and anxiety frequently occur together clinically and are fundamentally adverse psychological symptoms, which can also be seen from our association matrix (Appendix A). Additionally, depression is the leading cause of suicide (Im et al. 2017), and suicide tendency as the severe phenotype of depressive symptoms (Dong et al., 2018). Whereas positive psychological outcomes should be measured separately for empathy. In total, we built $2 \times 3 = 6$ models. We ruined SEM under STATA 16 (StataCorp LP, College Station, TX, USA). The results include the path coefficient with the level of significance and goodness of fit of the model.

Second, to verify the associations between subcultural identity and psychological outcomes, we built neural network (NN) based on a deep-learning algorithm. The NN metrics can be quantified using numerical values. Once the network is trained to fit the values, we can reveal the potential associations within the metrics by modifying specific inputs of the network and observing the corresponding outputs.

The NN we built were composed of several dense layers as shown in Figure 2. First, NN with one hidden layer of 16/32/64 units were constructed. And then NN with two hidden layers of 32 units in each layer were tested. In the end, NN with three hidden layers, with 32 units in each layer were applied. We changed the number of layers and units to observe the influence of the network width and depth on prediction accuracy. The inputs were five subcultural identities: ACG, idol, sport, fashion, and hip-hop.

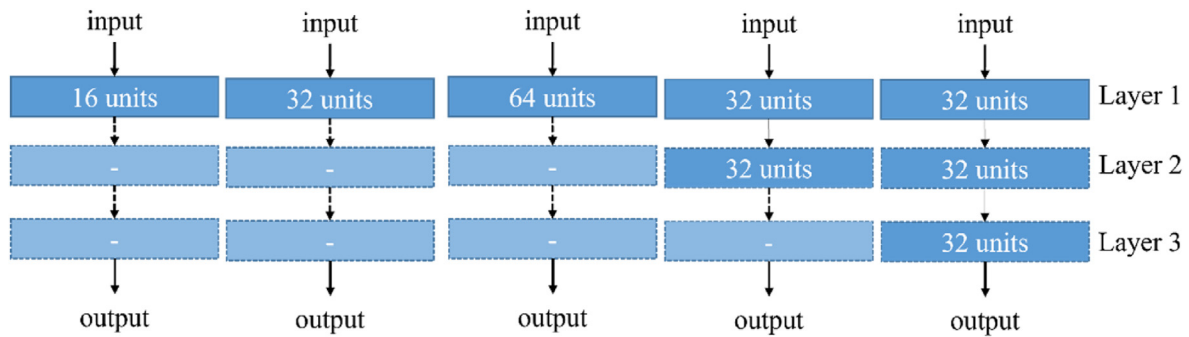


Figure 2. Network structure.

ReLU was used as the activation function for the hidden layers as it is less computationally expensive and often generate good performance (Agarap, 2018). The output was fed to linear activation for psychological outcomes: depressive symptoms, aggression, anxiety, suicidal tendency, and empathy.

3. Results

Table 1 presents the basic information on the sample. The variables' correlation matrix is presented in Appendix A. It shows that most of our variables interact with each other, among which the associations of five subcultural identities are also significant, indicating that the subculture identity we measured collapsed, so it was necessary to proceed with the structure equation model.

Table 1. Demographic character.

	Mean	Std. Deviation	Min	Max
Age	21.29	4.331	15	29
Subculture identity				
ACG	2.977	1.855	1	7
Sports	3.030	2.004	1	7
Idol	2.180	1.662	1	7
Fashion	2.546	1.692	1	7
Hip-hop	2.163	1.525	1	7
Reputation				
Group reputation	3.530	1.595	1	7
Personal reputation	3.460	1.597	1	7
Social support				
Emotional support	0.050	0.023	0.022	0.111
Instrumental support	0.087	0.043	0.033	0.167
Perceived support	0.067	0.033	0.029	0.143
Empathy				
Empathetic concern	22.233	3.312	11	33
Perspective taking	21.413	3.443	12	35
Fantasy scale	21.446	4.123	11	34
Personal distress	21.587	4.138	8	34
Aggression				
Anger state	17.160	7.428	10	40
Anger trait	20.630	7.393	10	40
Anxiety				
Anxiety state	45.273	10.747	20	79
Anxiety trait	50.100	3.111	40	62
Depression				
Beck Depression Inventory-II	16.987	13.672	0	63
Suicidal tendency				
Suicidal ideation scale	2.677	3.156	0	12

N 300; 150 female 150 males; Single 291 Married 9; student 170; informal employment 32; formal employment 48; civil servant 7; self-employed 4; freelancer 5; housewife 9; no job 15; medical service 4; others 6.

3.1. Results of the structural equation models

Figure 3 presents standardized results of structural models (1) (2) (3). In the first SEM model, a higher level of latent subculture identity was associated with adverse psychological symptoms directly ($\beta_{direct} = .22, p < 0.01$). Second, direct effect of subcultural identity on reputation is seen ($\beta_{direct} = .48, p < 0.001$), so well as reputation's direct effect on adverse psychological outcomes ($\beta_{direct} = -.26, p < 0.01$). Therefore, mediation effect of reputation on the association between subculture identity and adverse psychological outcomes is significant ($\beta_{indirect} = -.21, p < 0.01$). Similarly, in structural model (2), latent subculture identity was directly associated with psychological outcomes constructed by indicators of depressive symptom and suicidal tendency ($\beta_{direct} = .33, p < 0.001$), and the association is stronger than model (1). This might be due to the relation of depression and suicidal tendency ($\beta = .618, p < 0.05$ in Appendix A) is stronger than connection between depression and aggression or anxiety ($\beta = .515, p < 0.05$ and $\beta = .566, p < 0.05$ in Appendix A). Also, mediation effect of reputation on the association between subculture identity and adverse psychological outcomes is significant ($\beta_{indirect} = -.23, p < 0.01$). In model (3), direct association between subcultural identity and empathy is not significant ($\beta_{direct} = -.15, p > 0.05$) but still, mediation effect of reputation exists in this line ($\beta_{indirect} = .68, p < 0.01$). The first three models indicated reputation's significant role in youth psychological outcomes, that higher reputation youth identified with ACG, idol, hip-hop culture perceived, the less likely they could develop depressive symptom, suicidal tendency, aggression, anxiety status but more likely to be empathetic towards others. On the other hand, as subculture identity was not significantly associated with social support ($\beta_{direct} = -.084, p > 0.05$, $\beta_{direct} = -.084, p > 0.05$, $\beta_{direct} = -.077, p > 0.05$ respectively), the mediation effect is not valid.

Figure 4 presents standardized results of structural models (4) (5) (6), where identification with sports and fashion were used to construct latent subcultural identity. First, no direct association with psychological symptom was observed. Compared with first three models, the coefficient value of subcultural identity and reputation were higher ($\beta_{direct} = .82, p < 0.001$, $\beta_{direct} = .81, p < 0.001$ and $\beta_{direct} = .82, p < 0.001$ for model (4) (5) (6)). However, direct effect of reputation on psychological symptoms was not significant ($\beta_{direct} = -.36, p > 0.05$, $\beta_{direct} = -.42, p > 0.05$ and $\beta_{direct} = .42, p > 0.05$ in model (4) (5) (6)). This indicating although youth identified with sports or fashion culture enjoyed higher reputation, it had not affected depression, aggression, anxiety, suicidal tendency, or empathy. It might because youth attracted to sports and fashion already possessed better mental status, therefore, reputation from outside does not matter so much for their inner mental situations. As reputation's direct effect on psychological outcomes was not significant in this group, the mediation effect of reputation was not eminent. Also, subculture identity was not significantly associated with social support ($\beta_{direct} = .13, p > 0.05$, $\beta_{direct} = .13, p > 0.05$, $\beta_{direct} = .12, p > 0.05$ respectively), the mediation effect is not valid.

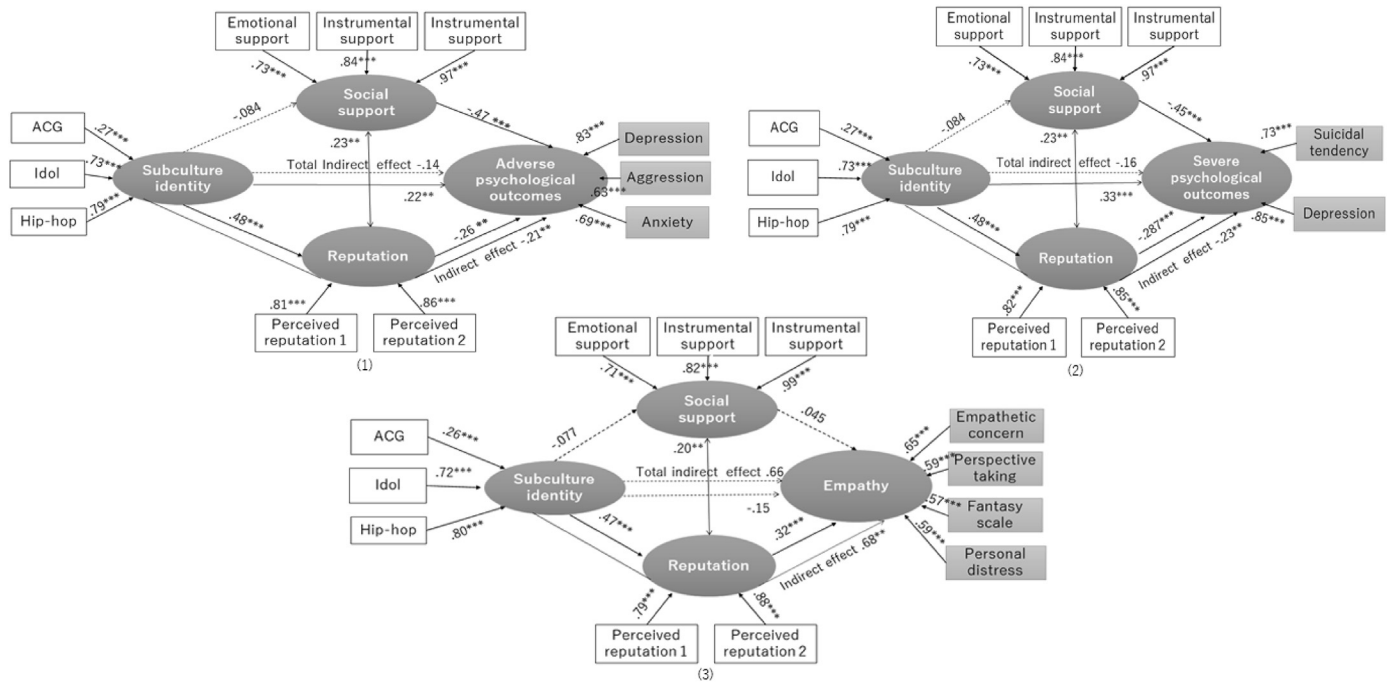


Figure 3. Standardized results of structural model (1) (2) (3), *p < 0.05 **p < 0.01 ***p < 0.001.

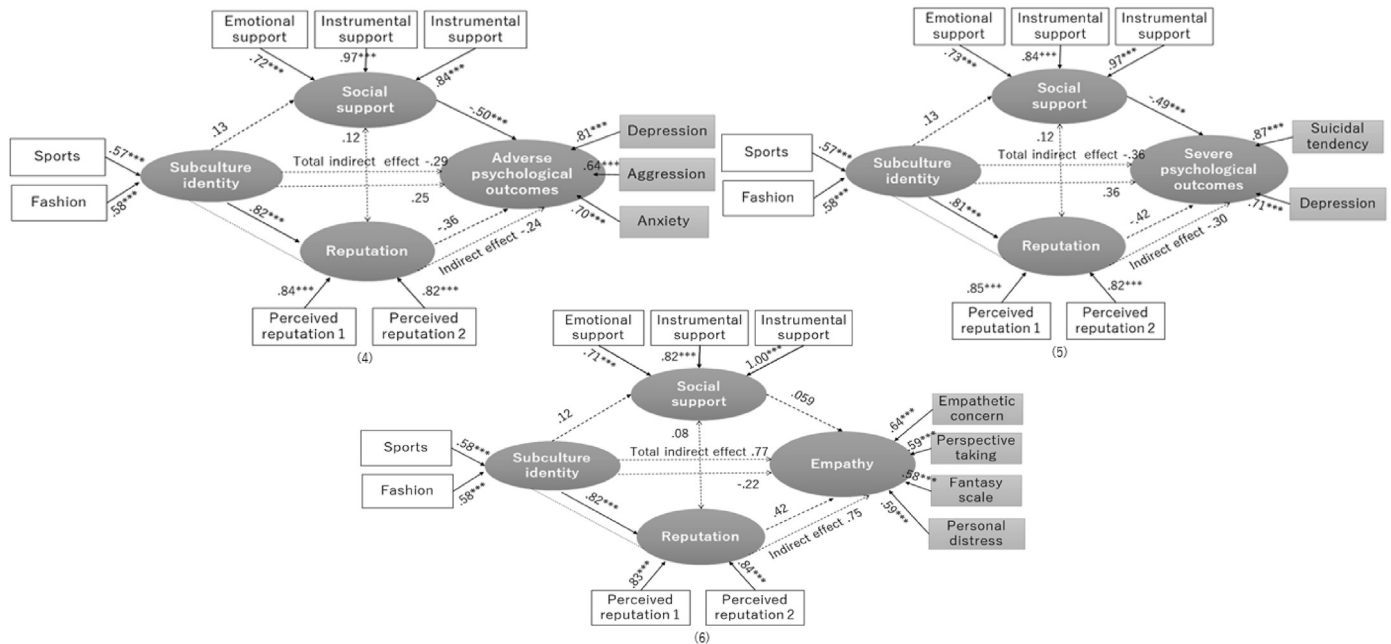


Figure 4. Standardized results of structural model (4) (5) (6), *p < 0.05 **p < 0.01 ***p < 0.001.

3.2. Goodness of fit

Table 2 presents goodness of fit of the six structural models we built. The CFI, denoted comparative index, TLI, denoted Tucker-Lewis index, the root mean square error of approximation (RMSEA), Standardized Root Mean Square Residual (SRMR) index and χ^2 were usually used to measure the performance of the structural equation model. Values of CFI above .95, TLI above .90, RMSEA and SRMR less than .08 indicating SEM is acceptable (Hu and Bentler, 1999). A significant χ^2 value means that we can reject a poor fit. However, researchers have pointed out that it is sensitive to sample size; the larger the sample, the greater the chance of obtaining a significant level. Therefore, some scholars recommend using the division of (χ^2 /df) as a measure of good fit, with values of 5 or less being a common

benchmark (Schumacker and Lomax, 2004). Following these criteria, we built six structural equation models that are acceptable. The R square shows that above 70% of the variance is explained by our arrangements.

4. Deep learning result of subculture identity and psychological outcomes

As shown in Table 3, we built NN with various structure. First, NN with 1 layer and 16/32/64 units applied five categories of subcultural identity as input and depressive symptom, suicidal tendency, empathetic value, anxiety, aggression as outputs together; and then we extend the depth of NN to 2 layers and 3 layers, within which each layer contains 32 units. To improve the NN stability and accuracy, NN structure with more

Table 2. Goodness of fit summary.

Structural equation model	χ^2 (df) model vs saturated	P	R squared	CFI	TLI	RMSEA	SRMR
(1)	86.89 (38)	0.000	0.769	0.961	0.944	0.066	0.052
(2)	75.27 (29)	0.000	0.774	0.961	0.940	0.073	0.053
(3)	110.98 (48)	0.000	0.769	0.946	0.926	0.066	0.064
(4)	66.72 (29)	0.000	0.755	0.968	0.951	0.066	0.046
(5)	60.316 (21)	0.000	0.760	0.965	0.939	0.079	0.049
(6)	85.867 (38)	0.000	0.754	0.956	0.937	0.065	0.056

CFI = Comparative fit index; TLI = Tucker-Lewis index.

complexity, 2 layers with 32 units in each layer was trained focusing on single psychological symptom. Each NN model was trained for 1000 epochs.

A total of 300 samples was collected, where 80% (n = 240) samples were randomly chosen as the training dataset to build the NN model, and 20% (n = 60) were used for validation. The ratio of training/testing set was decided arbitrarily as the total amount of data is relatively small. K-fold cross validation method was applied (K = 5 corresponding the ratio of training/testing) to randomly and averagely separated the data into five sets.

All of the data were normalized to the range between zero and one before being input into the network to remove the influence from different value ranges. The outputs were rescaled to the original range. Prediction's accuracy and Mean Squared Error (MSE) were used to report performance of NN in Table 3. Prediction's accuracy was calculated as:

$$Accuracy = \frac{n_{true}}{n_{total}}$$

n_{true} refers to the number of predictions that match our data and n_{total} is the total number of predictions.

Panel A in Table 3 presents the accuracy of the NNs using all psychological outcomes as outputs together. The difference between training and testing prediction accuracy suggested that our NN suffered from underfitting problems. Such variation was predictable to some extent as the amount of output variables outnumbered input variable. Also, sparse units or simple layers of NN structure cannot extract sufficient features from inputs for prediction. However, this does not mean that more units are good for prediction, because they may cause overfitting problems (Schmidhuber, 2015). Panel B reports the accuracy of NNs using each psychological outcomes separately as outcome. Except NN for depressive symptom, there is a rise in accuracy compared with NN integrated all psychological indicators together as outputs. Therefore, it is reasonable to say that due to the limited scale of collected dataset, one inputs character and asymmetrical amount of output characters, other than the lack of variable association, the initial NNs did not perform well. The highest accuracy was obtained in the NN test for anxiety (71.6% for the training

Table 3. Performance of NNs.

Structure	Accuracy in Training Set %	MSE	Accuracy in Validation Set %	MSE
Panel A: All the psychological indicators as outputs				
16	20.8333	0.034	20.000	0.045
32	24.5833	0.032	25.000	0.046
64	25.8333	0.031	23.333	0.047
32-32	25.4167	0.029	25.000	0.045
32-32-32	25.8333	0.027	28.333	0.044
Panel B: Single psychological indicators as output in 2 layers 32-32 units' network				
Depressive symptom	8.745	0.031	6.667	0.049
Suicidal tendency	44.556	0.051	48.333	0.067
Emphatic value	54.155	0.014	56.667	0.021
Anxiety	71.600	0.013	56.667	0.021
Anger state	45.000	0.043	33.400	0.063

set, 56.6% for validation). The increase in accuracy indicated that a more delicate NN could serve well to predict specific psychological symptom.

Finally, we present the prediction of psychological outcomes in the NN with two layer, 32-32 units because it provides more accuracy. For simplicity, we activated only one specific subcultural identity input and observed the output results. Table 4 presents the results. Overall, the prediction from NN is in line with our statistical findings that ACG, idol, and hip-hop identity could result in higher depression and suicidal tendencies than sports and fashion identity. What is interesting here is that ACG identity was predicted to have the highest empathy value. This may relate to the rich imagination contained in anime and manga, and imaging other situations may be a first step to empathy.

5. Discussion

This study examined the integration of subcultural identity, social support, reputation, and various psychological outcomes. In the analysis of structural equation modeling, ACG, idol, and hip-hop identity were related to adverse psychological outcomes, whereas fashion and sports identity were not. Similarly, the neural networks we built predicting relatively severe psychological outcomes followed with ACG, idol and hip-hop identity. The negative association between ACG, idol, hip-hop identity and adverse psychological symptoms can be mediated by reputation.

Table 4. Results in 32-32 NN.

Inputs	Prediction
ACG: 7	Depression: 26 Suicidal tendency: 3 Anger state: 17 Anger trait: 25 Empathy: 92 Anxiety: 89
Sports: 7	Depression: 11 Suicidal tendency: 1 Anger state: 13 Anger trait: 18 Empathy: 83 Anxiety: 94
Idol: 7	Depression: 17 Suicidal tendency: 5 Anger state: 17 Anger trait: 21 Empathy: 85 Anxiety: 90
Fashion: 7	Depression: 11 Suicidal tendency: 0 Anger state: 10 Anger trait: 10 Empathy: 88 Anxiety: 103
Hip-hop identity: 7	Depression: 24 Suicidal tendency: 2 Anger state: 10 Anger trait: 22 Empathy: 91 Anxiety: 88

Specifically, ACG, idol, and hip-hop identity were negatively and significantly related to depressive symptom, suicidal tendency, anxiety status, and aggression, indicating youth who identified with above mentioned subculture elements were related with adverse mental problems. Such relation is not true for fashion and sports identities. Thus, H1 'Different subcultural identities are associated with various psychological outcomes' was proved. Second, all measured subcultural identities were weakly related to social support, indicating that H2 is invalid, that social support could not mediate the association between subculture identity and psychological outcomes. Third, for ACG, idol and hip-hop group, reputation had a significant mediating effect on both adverse psychological outcomes and empathy. Conversely, the mediation effect for sports and fashion groups was not significant. Therefore, H3 'Different subcultural identities are associated with various psychological outcomes, and they are mediated by reputation' was true for ACG, idol and hip-hop group.

Our findings accord with previous findings that different subcultures follow various psychological outcomes (Bowes et al., 2015; Levine et al., 2005). The difference may relate to the subculture's interpretation frame. For example, in the Ana group, vomiting and starvation were seen as justifiable acts (Gailey, 2009). Similarly, it is usual to see bitter and hopeless characters in various anime; young adults may be influenced by the attitude anime transfer and develop mental health problems. Regarding empathy, we found no significant association with any subculture. Our results suggest that subcultural enthusiasm may be a predictor for mental health problems, but not empathy.

The reason of positive relation between reputation and subcultural identity may stem from Japanese collectivism; one's community belongingness is usually highly appreciated. These findings may be differentiated from previous studies that teenage enthusiasm for anime or idol fans is discriminated against in school (Leshner et al., 2018). Further, reputation in the ACG, idol, and hip-hop groups could mediate adverse psychological outcomes, but not in the sports and fashion groups. Previous studies showed positive reputation linked with psychological well-being (Foster et al., 2021); our study goes further. We found that the effect of reputation may matter more for youth identified with stigmatized groups. Therefore, future de-stigmatization work for disadvantaged groups is urgently needed.

As for the results of NN, the highest predictive accuracy of 71% was seen in NN with 2 layers, 32-32 structure to predict anxiety. Although the NN models with 1 layer we originally built present underfitting problem, after extending the depths and width of the network structure, the rise of predicting accuracy were observed. The rise of predictive accuracy indicating that NN with more delicate structure could predict individual psychological status based on cultural preferences. NN shows that Artificial Intelligence could serve as a robust tool to manage public health problems as a simple and inexpensive way to detect cultural differentiation or various diseases.

This study also has various limitations. First, we recruited participants from an online research company in Japan, which could result in selection bias that are not representative for a general population. Second, only one item was used to measure subcultural identity, which may weaken the relationships between subcultural identity and psychological measurements, making results less reliably. Third, the five subcultural identities have largely collapsed, and we cannot separate the different effects associated with different subculture crystal clear. Further study needs to adopt a more inclusive measurement on evaluating identity in each of subculture group independently. Fourth, this study doesn't contain causal examination, therefore it could be possible that youth who already developed psychological problems are easier to be attracted by anime, idol and hip-hop culture to ease their original metal suffers. Fifth, the difference of mediating effect of reputation might be predictable corresponding to the reputation variance followed with subcultural elements, that anime or idol fandom usually comes with stigma but being sporty and fashionable could bring popularity to youth (Leshner et al., 2018; Ishii, 2014). Sixth, our outcome measurements were restricted to psychological symptoms, but physical or behavioral outcomes relate with subculture were not considered. Therefore, outcomes such as eating disorders or delinquency might be associated with fashion or hip-hop

subgroups and should be studied in future research. Finally, the predictive accuracy of NN was not as expectation, which ascribe to limited amount of data and asymmetric number of input and output variables, therefore the improvement of NN structure and more representative data focusing on subculture preference is expected.

Subculture, such as animation, K-pop idol fandom, rock music, does not only influence on youth perspectives towards life (Ramasubramanian and Kornfield, 2012; Rustad et al., 2003), but also socialization process and tangible lifestyle, such as consumption of idol related commercial item, participation in the community of fandom (Siriyuvasak and Hyunjoon, 2007). As attitude, social activity are the crucial facilitators of mental health problem, subcultures importance on public health management is evident. Our study contributes to this line of concerns, we proved that identification towards subculture associated with psychological symptoms and such association is predictable by deep learning neural networks. As teenagers are the population with most sensitive personality, it's better to measure and enhance their mental health status indirectly than interfere directly. Deep learning on cultural preferences may provide a new solution to do that: without diagnosing clinical symptom but focusing on cultural enthusiasm of the patients to predict their potential mental health status, through which decrease the feeling of shame and avoid stigma related with disease. In the end, we call for future research at a more representative level for subcultural group and discuss its causal relation with health problems.

6. Conclusion

ACG, idol, and hip-hop culture identities are associated with adverse psychological outcomes (i.e., depressive symptoms, anxiety, suicidal ideation, aggression), and reputation is a robust mediating variable of such an association.

Declarations

Author contribution statement

Yinghao Liu; Yingxu Liu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jiahao Wen: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Funding statement

This research is supported by the WISE Program on AI Electronics by Tohoku University and MEXT's University Fellowship Founding Project for Innovation Creation in Science and Technology.

Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

The author would like to thank Yingxu Liu, Jiahao Wen and anonymous reviewers for their contribution. This research is supported by the WISE Program on AI Electronics in Tohoku University and MEXT's University Fellowship Founding Project for Innovation Creation in Science and Technology.

Appendix A. Correlation Matrix with significant level

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. ACG identity	1														
2. idol identity	0.2053*	1													
3. hips identity	0.1669*	0.5875*	1												
4. fashion identity	0.2843*	0.5034*	0.5862*	1											
sports identity	0.2431*	0.1992*	0.3640*	0.3334*	1										
6. emotional support	-0.0008	-0.0489	-0.0565	0.1008	0.1908*	1									
7. instrumental support	0.076	-0.0934	-0.1101	-0.0147	0.1006	0.5682*	1								
8. perceived support	0.0562	-0.0599	-0.0634	0.0207	0.1157*	0.7081*	0.8152*	1							
9. perceived reputation 1	0.2834*	0.1998*	0.2999*	0.3941*	0.3884*	0.1711*	0.2206*	0.17	1						
10. perceived reputation 2	0.2509*	0.2988*	0.3344*	0.3992*	0.3928*	0.1065	0.1504*	0.0736	0.6957*	1					
11. depression	0.0152	0.1271*	0.1288*	-0.0078	-0.0078	-0.4553*	-0.4105*	-0.4144*	-0.1957*	-0.1501*	1				
12. suicidal tendency	0.0673	0.1903*	0.1806*	0.0727	-0.036	-0.3892*	-0.3136*	-0.3560*	-0.112	-0.0374	0.6182*	1			
13. aggression	0.0095	0.0571	0.0487	-0.0068	-0.0099	-0.2825*	-0.2332*	-0.2975*	-0.0652	-0.0846	0.5148*	0.4015*	1		
14. anxiety	-0.0424	0.0027	-0.0012	-0.0566	-0.1141*	-0.3833*	-0.3064*	-0.3374*	-0.1878*	-0.1339*	0.5655*	0.4757*	0.4751*	1	
15. empathy	0.1724*	0.0162	-0.0231	0.0688	0.0418	0.048	0.1174*	0.0642	0.1446*	0.1858*	0.0403	0.057	0.0009	0.02	1

* denote significant level lower than 0.05.

References

Agarap, Abien Fred, 2018. Deep Learning Using Rectified Linear Units (ReLU).
 Bogt, Tom F.M. Te, Keijsers, Loes, Meeus, Wim H.J., 2013. Early adolescent music preferences and minor delinquency. *Pediatrics* 131 (2), e380–e389.
 Bowes, Lucy, Carnegie, Rebecca, Pearson, Rebecca, Mars, Becky, Biddle, Lucy, Maughan, Barbara, Lewis, Glyn, Fernyhough, Charles, Heron, Jon, 2015. Risk of depression and self-harm in teenagers identifying with goth subculture: a longitudinal cohort study. *Lancet Psychiatr.* 2 (9), 793–800.
 Chandler-Olcott, Kelly, Mahar, Donna, 2003. Adolescents' anime-inspired 'fanfiction': an exploration of multiliteracies. *J. Adolesc. Adult Literacy* 46 (7), 556–566.
 Cobb, S., 1976. Social support as a moderator of life stress. *Psychosom. Med.* 38 (5), 300–314.
 Crooke, Alexander Hew Dale, Comte, Rachael, Moreno Almeida, Cristina, 2020. Hip hop as an agent for health and wellbeing in schools. *Voices: World Forum Music Therapy* 20 (1).
 Crowe, N., Hoskins, K., 2019. Researching Transgression: Ana as a Youth Subculture in the Age of Digital Ethnography. *Societies, and Undefined* 2019. Mdpi.Com.
 Cuypers, Koenraad, Krokstad, Steinar, Holmen, Turid Lingsaas, Knudsen, Margunn Skjei, Bygren, Lars Olov, Holmen, Jostein, 2012. Patterns of receptive and creative cultural activities and their association with perceived health, anxiety, depression and satisfaction with life among adults: the HUNT study, Norway. *J. Epidemiol. Community Health* 66 (8), 698–703.
 Dong, Min, Wang, Shi Bin, Li, Yan, Xu, Dan Dan, Ungvari, Gabor S., Ng, Chee H., Chow, Ines H.I., Xiang, Yu Tao, 2018. Prevalence of suicidal behaviors in patients with major depressive disorder in China: a comprehensive meta-analysis. *J. Affect. Disord.* 225, 32–39.
 Doosje, Bertjan, Ellemers, Naomi, Russell, Spears, 1995. Perceived intragroup variability as a function of group status and identification. *J. Exp. Soc. Psychol.* 31 (5), 410–436.
 Foster, Stephen, Carvalho, Mauricio, Lee, Jongwon, Bernier, Itzel, 2021. Honor and seeking mental health services: the roles of stigma and reputation concerns. *J. Cross Cult. Psychol.* 52 (2), 178–183.
 Gailey, Jeannine A., 2009. 'starving is the most fun a girl can have': the pro-ana subculture as edgework. *Crit. Criminol.* 17 (2), 93–108.
 Gottlieb, Troels, Furnham, Adrian, Klewe, Jeppe Brændskov, 2021. Personality in the light of identity, reputation and role taking: a review of socioanalytic theory. *Psychology* 12 (12), 2020–2041.
 Gottlieb, Troels, Göttsche-Astrup, Oluf, 2020. Personality and work-related outcomes through the prism of socioanalytic theory: a review of meta-analyses. *Nord. Psychol.* 72 (4), 346–362.
 Haslam, S. Alexander, O'Brien, Anne, Jetten, Jolanda, Vormedal, Karine, Penna, Sally, 2005. Taking the strain: social identity, social support, and the experience of stress. *Br. J. Soc. Psychol.* 44 (3), 355–370.
 Hogan, R., 1983. A socioanalytic theory of personality. In: *Nebraska Symposium on Motivation. Nebraska Symposium on Motivation*, pp. 55–89.
 Horowitz, Ruth, Vigil, James Diego, 1990. Barrio gods: street life and identity in Southern California. *Contemp. Sociol.* 19 (1), 96.
 Hu, Li Tze, Bentler, Peter M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model.* 6 (1), 1–55.
 Im, Yeojin, Oh, Won Oak, Suk, Minhyun, 2017. Risk factors for suicide ideation among adolescents: five-year national data analysis. *Arch. Psychiatr. Nurs.* 31 (3), 282–286.
 Ishii, Hisao, 2014. Human Development and Education : Meiji Gakuin University Teacher Certification Program Review. In: *A Study on the Diversity of School Caste*, vol. 10, pp. 97–117.
 Iwata, Noboru, Mishima, Norio, 2016. Reliability of the state-trait anxiety inventory. *Form Y in Jpn. Samples* 84 (2), 494–496.
 Kojima, Masayo, Furukawa, Toshiaki A., Takahashi, Hidekatsu, Kawai, Makoto, Nagaya, Teruo, Tokudome, Shinkan, 2002. Cross-cultural validation of the Beck depression inventory-II in Japan. *Psychiatr. Res.* 110 (3), 291–299.
 Leicht-Deobald, Ulrich, Bruch, Heike, Bönke, Luisa, Stevense, Amie, Fan, Yan, Bajbouj, Malek, Grimm, Simone, 2018. Work-related social support modulates effects of early life stress on limbic reactivity during stress. *Brain Imag. Behav.* 12 (5), 1405–1418.
 Leshner, Connor, Reysen, Stephen, Plante, Courtney N., Chadborn, Daniel, Roberts, Sharon E., Gerbasi, Kathleen C., 2018. 'My group is discriminated against but I'm not': Denial of personal discrimination in furry, brony, anime, and general interest fan groups. *Phoenix Pap.* 4 (1), 130–142.
 Leshner, Connor, Plante, Courtney N., Reysen, Stephen, Roberts, Sharon E., Gerbasi, Kathleen C., 2020. Behind closed doors: Hentai fans' perceived discrimination, ingroup identification, and attitudes toward subgroups in the anime fandom. *Phoenix Pap.* 4 (2), 104–118.
 Levine, Mark, Amy Prosser, Evans, David, Reicher, Stephen, 2005. Identity and emergency intervention: how social group membership and inclusiveness of group boundaries shape helping behavior. *Journals.Sagepub.Com* 31 (4), 443–453.
 McNamara, Niamh, Stevenson, Clifford, Costa, Sebastiano, Bowe, Mhairi, Wakefield, Juliet, Kellezi, Blerina, Wilson, Iain, Moon, Halder, Mair, Elizabeth, 2021. Community identification, social support, and loneliness: the benefits of social identification for personal well-being. *Br. J. Soc. Psychol.* 60 (4), 1379–1402.
 Ramasubramanian, Srividya, Kornfield, Sarah, 2012. Japanese anime heroines as role models for U.S. Youth: wishful identification, parasocial interaction, and intercultural entertainment effects. *J. Int. Intercult. Commun.* 5 (3), 189–207.
 Robinson, Cendrine, Seaman, Elizabeth L., Montgomery, La Trice, Winfrey, Adia, 2018. A review of hip hop-based interventions for health literacy, health behaviors, and mental health. *J. Racial Ethnic Health Disparities* 5 (3), 468–484.

- Rustad, Robin A., Small, Jacob E., Jobes, David A., Safer, Martin A., Peterson, Rebecca J., 2003. The impact of rock videos and music with suicidal content on thoughts and attitudes about suicide. *Suicide Life-Threatening Behav.* 33 (2), 120–131.
- Sato, Hiroshi, Sato, Miyuki, Mitamura, Takashi, 2014. Psychometric properties of the Japanese version of the suicidal ideation questionnaire-JR in Japanese College students. *Jpn. J. Clin. Psychol.* 14 (3), 395–401.
- Schmidhuber, Jürgen, 2015. Deep learning in neural networks: an overview. *Neural Network.* 61, 85–117.
- Schumacker, Randall E., Lomax, Richard G., 2004. *A Beginner's Guide to Structural Equation Modeling.*
- Seggar, Leslie B., Lambert, Michael J., Hansen, Nathan B., 2002. Assessing clinical significance: application to the Beck depression inventory. *Behav. Ther.* 33 (2), 253–269.
- Shildrick, Tracy, MacDonald, Robert, 2006. In defence of subculture: young people, leisure and social divisions. *J. Youth Stud.* 9 (2), 125–140.
- Shimoda, Yoshiyuki, Terasaka, Akiko, 2012. Reliability and validity of the Japanese version of the multidimensional school anger inventory. *Shinrigaku Kenkyu : Jpn. J. Psychol.* 83 (4), 347–356.
- Siriyuvasak, Ubonrat, Hyunjoon, Shin, 2007. Asianizing K-pop: production, consumption and identification patterns among Thai youth. *Inter Asia Cult. Stud.* 8 (1), 109–136.
- Wann, Daniel L., Stephanie, Pierce., 2005. The relationship between sport team identification and social well-being: additional evidence supporting the team identification -social psychological health model. *N. Am. J. Psychol.* 7 (1), 117–124.
- Wihler, Andreas, Meurs, James A., Wiesmann, Daniela, Troll, Leander, Blicke, Gerhard, 2017. Extraversion and adaptive performance: integrating trait activation and socioanalytic personality theories at work. *Pers. Individ. Differ.* 116, 133–138.
- Xiao, Yuzhi, Toyama, Miki, 2020. Development of a Japanese version of the interpersonal behaviours questionnaire. *Shinrigaku Kenkyu* 90 (6), 581–591.
- Zimet, Gregory D., Dahlem, Nancy W., Zimet, Sara G., Farley, Gordon K., 1988. The multidimensional scale of perceived social support. *J. Pers. Assess.* 52 (1), 30–41.