The interaction between serotonin transporter allelic variation and maternal care modulates sociability on Instagram

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Abstract

In both physical and online environments, human social interactions can represent a means to gain recognition and approval from others. While there is considerable evidence about the interaction between genetics and the environment on social development, studies adopting the same framework to investigate online social interactions are lacking. The present work applies a model from behavioural genetics on Instagram sociability to explore the impact of individual development on social media platforms' behaviour.

We hypothesized that social attitudes on Instagram resulted from an interaction between serotonin transporter gene alleles and the individual's remembrance of the interaction with caregivers. We assessed the environmental and genetic components of 57 Instagram users, adopting the *Parental Bonding Instrument* to determine the perceived parental care and overprotection. The number of posts followed by users ("followings") and followers were collected from participants' Instagram profiles as online social activity indexes. Additionally, the ratio between the number of followers and followings ("Social

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Desirability Index”) was calculated to estimate each user’s social network’s asymmetry. Finally, information on the polymorphism rs25531 (T/T homozygotes vs C-carriers) within the serotonin transporter gene was extracted from participants’ buccal mucosa cell samples.

In line with the predictions, we found a gene-environment interaction on the ”Social Desirability Index”: users with the genotype more sensitive to environmental influences (T/T homozygotes) showed a higher Instagram ”Social Desirability Index” than less sensitive ones (C-carriers) when positive maternal care was experienced.

This result may contribute to the understanding of online social behaviour from a gene*environment perspective.

Keywords: Gene * Environment, Parental Bonding, Maternal Care, Serotonin Transporter Gene, rs25531, Instagram, Social Media, Social Network Sites, Online Behavior, Instagram

Introduction

Among the early environmental factors, parent-infant interaction modulates human development on a biological level, influencing social, emotional and cognitive domains [1]. Efficient parenting promotes an inclusive environment, fostering patterns for high-quality social relationships in childhood [2, 3] which, in turn, can decrease behavioral and physiological distress in adulthood [4]. Simultaneously, different long-term environmental factors can play an active role in the modulation of sociality across the human lifespan. From the first years of their lives, children are increasingly exposed to technological devices [5], and begin to use mobile technologies before school age [6]. This may contribute to social competencies learning in both online and offline worlds [7]. Increasingly, younger and younger individuals - as age limits can be easily deceived - can access social network sites (SNSs), where social exchanges between users are immediate, free, continuous and pervasive [8]. Among these sites, Instagram (IG) is a photo- and video-sharing platform where users can follow stories, publish or comment on posts, watch or upload content, and chat privately. Some evidence demonstrated that increased Instagram activity might be associated with positive outcomes, acting as a motivator for a satisfying self-presentation and increasing self-confidence [9], but it is also associated with negative consequences, like a risk to the development of a depressed mood [10] and a detrimental effect on mental well-being

[11].

However, the influence of environmental cues might not fully explain such a tangled phenomenon, such as social behaviour. According to the biopsychosocial model of wellness and illness, it is more likely that genetic predispositions could be crucial in shaping the effect of early experiences on social conduct on SNSs. At the molecular level, individual behaviours result from genetic predispositions and environmental stressors or conditions, especially during critical periods [12]. According to the *differential susceptibility model* [13] a given genetic predisposition is not uniquely “good” or “bad” in human behaviour. Indeed, the level of susceptibility to life events is flexible and regulated by the allelic expression involved in the physiological and behavioural responses to a range of triggering environmental hazards. In the myriad of biological regulators, serotonin is a neurotransmitter implicated in the neural circuits of emotional regulation, social functioning and social affiliation [14, 15]. Serotonin level may vary across brain regions and may have different effects on individuals [16]. The serotonin transporter encoded by the serotonin transporter gene (SLC6A4) is the main regulator of the serotonin removal from the synaptic clefts. Specifically, the promoter region of the serotonin transporter gene (5-HTTLPR) and the adjacent upstream polymorphism (5-HTT rs25531) [17, 18] have been investigated in association with perceived attachment and parental attitudes [19, 20, 21]. Concerning 5-HTTLPR, for instance, Truzzi et al. [22] discovered that men with a higher predisposition (carriers of the short form of 5-HTTLPR) for sensitivity to maternal overprotection showed distressed heart rate to female cry. Concerning rs25531, two allelic forms have been found: the substitution of thymine (T) and cytosine (C), with the paired nucleotides guanine (G) and adenine (A), shows differential susceptibility to stressors [23, 24, 25]. However, until now, literature has not been able to disentangle which variation is more associated with adaptive social responses [26, 27]. Genetic vulnerability conferred by the A/A and T/T genotype, whose transcription processes are associated with a lower re-uptake of serotonin, can be moderated by social support of parents [28]. The degree of social support received in childhood rules the risk towards mental disorders in adulthood and facilitated a wide range of possible behavioural outcomes [24, 29]. For instance, people with a history of low-quality parental support in childhood could show maladaptive behaviours, and a greater benefit from others’ support in adulthood [30, 31, 32, 33]. Conversely, individuals with the C or G allele showed enhanced serotonin degrees combined with lessened sensitivity to pain, traumatic events, and

care [25]. Within the social context, higher social avoidance and lower emotional engagement were related to a decrease of serotonin, whereas higher prosocial behaviour and lower social anxiety from childhood were related to an increase in serotonin [20, 24].

In summary, we could assert that sociability emerges from the combined effects of nature, driven by genetic and biological predispositions, and nurture (e.g., social environment, social education across development, social experiences with parents and peers) [12]. However, the function of the “sociability genes” (i.e. 5-HTT rs25531) according to the early environment’s quality on the online social interaction of adults is not yet investigated.

Therefore, this research explores how the serotonin transporter gene and the individual’s relationship with caregivers during childhood interact in modulating adults’ online social interactions on Instagram. Our attention focused on Instagram, one of the most popular social networks, to unveil online social interaction’s fundamental mechanisms. Instagram users were firstly required to fill the *Parental Bonding Instrument* as a measure of their recalled parental bonding. Buccal mucosa samples were subsequently collected and one 5-HTT single nucleotide polymorphism (SNP: rs25531) was examined as a genetic factor. Finally, three social media indexes were assessed from the Instagram profile of each user: the number of (i) published posts as an index of the social productivity of the network, (ii) number of followed users (here called “followings”) as a measure of prosocial activity, (iii) number of followers as a measure of the social attraction of other users. A fourth Instagram index was obtained as a proxy of asymmetry of the social network, calculated through the ratio between the number of followers and the number followings: (iv) the “Social Desirability Index” (SDI).

For each Instagram index as the dependent variable, we hypothesized an interaction effect between the genetic component and the attachment scores, independent of the gender. More precisely, we expected that adult Instagram users with a genetic risk factor (rs25531 T/T) who experienced a supportive and positive past relationship with parents (High Parental Care, Low Parental Overprotection) would show a greater online social activity compared to protective genetic carriers (rs25531 C-carriers). Although we formulated a directional hypothesis, we could not predict a-priori on which Instagram variable potential effects would have been displayed. Given the new role of Instagram activity under a gene-environment perspective, we adopted an exploratory approach.

Methods

Participants

Sixty-one ($N = 61$) young adults participated among the students of the Nanyang Technological University (Singapore). Inclusion criteria were: (i) no history of genetic, neurological or psychiatric disorders, (ii) age lower than 30 years old, and (iii) owning and using an Instagram account. Four participants were omitted due to technical issues; thus our final sample included 57 Singaporean non-parent adults (16 males and 41 females) aged 18-25 years old ($M = 20,82$, $SD = 1,59$).

Procedure

Before collecting data, participants provided informed consent and reported demographic details. The study included three assessments: 1) participants completed the self-report questionnaire *Parental Bonding Instrument* on the web-based survey platform Qualtrics and 2) supplied the link of their Instagram page from which a Python program extracted four parameters of their on-line activity. When the Python program failed, Instagram data was assessed manually. Finally, 3) a sample of buccal mucosa was collected from each participant and genotyped in the laboratory.

Parental Bonding

The *Parental Bonding Instrument* (PBI) [34] is a 50-item self-report questionnaire administered to adults to quantify their parental bonding during childhood and adolescence. This instrument allows participants to recollect the quality of the relationship with their parents, rating their caregiving behaviour on a 0-3 Likert scale. The PBI (averaged Cronbach's $\alpha = 0.88$ in our sample) provides an estimate of the reported early attachment across four subscales: maternal and parental care, maternal and parental overprotection (see Supplementary Materials). While the two dimensions of care evaluate the level of parental closeness and affection (e.g. “*Could make me feel better when I was upset*”), the two subscales of overprotection measure the level of parental imposition or detachment (e.g. “*Made me feel I wasn't wanted*”). The PBI is an instrument widely used worldwide with reliable psychometric properties in terms of high validity, internal consistency [35, 36], and previously used in gene*environment research paradigms [37, 22, 38].

Instagram Parameters

We selected four variables from Instagram data: *number of posts*, *number of followings*, *number of followers*, and *Social Desirability Index*. The number of posts describes the quantity of published and shared material on the participant’s profile. On Instagram, posts can usually be pictures, videos or graphical texts, all content that other users can actively comment on and like [39]. This parameter suggests the users’ level of productivity and desire for exposure to others’ judgements. The number of posts was also associated with the users’ psychological vulnerability (i.e. depression) [40]. The number of followings represents the amount of followed users by an assessed study participant. Instagram people compare their behaviour with other users who become the reference points of their virtual activity. More followings demand more social interactions in terms of greater time invested in online social activities and higher passive exposure to content published by other users [41, 42]. The number of followers is the number of users who follow the assessed study participant. Followers’ recognition and support act as a reward for the user’s online behaviour, who then adjusts his/her social activity in line with the social network’s requests to boost further agreeableness (i.e. the number of likes) [43]. The Social Desirability Index is obtained by the ratio between the number of followers and the number of followings. We calculated this ratio to explore the asymmetry between these two parameters in each participant’s network. As discussed in a previous work [38], this parameter has the potential to reveal “the tendency of some Instagram users of maximizing the number of followers at the expense of the number of followings”.

Genotyping

The same DNA sequencing technique adopted by Bonassi and colleagues [37] was used in this study. DNA extraction and genotyping were performed by ACGT, Inc. (Wheeling, IL) for the 5-HTT gene (SLC6A4) rs25531 region target. DNA was derived from each kit, applying the Oragene DNA purifying reagent. DNA concentrations were evaluated through spectroscopy (NanoDrop Technologies, USA). A polymerase chain reaction (PCR) reaction of 20 μ l including 1.5 μ l of genomic DNA from the test sample, PCR buffer, 1 mM of each primer (forward 5’-GGCGTTGCCGCTCTGAATGC-3’ and reverse 5’-GAGGGACTGAGCTGGACAACCCAC-3’) 10 mM deoxyribonucleotides, KapaTaq polymerase, and 50 mM MgCl₂ was administered. PCR operation consisted of first a 15 minute denaturation at 95 °C, and 35 cycles

at 94 °C (30 s), 60 °C(60 s), 72 °C (60 s) and a further 10 minute lengthening at 72 °C. PCR reactions were genotyped with an ABI 3730xl Genetic Analyzer (Applied Biosystems Inc.) and standardized with GeneScan 600 LIZ (Applied Biosystems, Inc.) size standards on each sample. Genotypic data were analyzed by GeneMapper ID (Applied Biosystems, Inc.).

The average distribution of the genotypes in the Asiatic population is 86-87% for T/T homozygotes and 13-14% for C-carriers¹, whereas the distribution in our sample was 73.68% for T/T homozygous (N = 42), 26.32% for C/T heterozygous (N = 15) and 0% for C/C homozygous (N = 0). This genotype distribution follows the Hardy-Weinberg Equilibrium ($X^2(1) = 1.31$, ns). Participants having one C allele (C/T) were classified into a single C-carriers group. Participant gender ($X^2(1) = 0.23$, ns) did not significantly differ between the two groups T/T vs C.

Analysis

Data were analyzed on R (version 4.0.0). Instagram variables were first standardized with z-scores (Table 1). Measured variable distributions were checked for normality, skewness, kurtosis, presence of outliers and were then visualized by density and quantile-quantile plots (Table 1).

The distance of each observation to the centroid was estimated to detect outliers defined with a value equal to 2 *SDs* above/below the mean [44]. Three extreme values were identified as outliers for the number of followings and the number of posts, two values for the SDI, and one value for the number of followers out of total 57 observations for each Instagram variable. They were replaced with the mean value in observations, obtained by excluding the outliers. Each Instagram variable showed a normal univariate distribution. Only the number of posts did not present a Gaussian distribution, and a logarithmic transformation was applied to allow for the adoption of parametric tests. Moreover, the assumptions of homogeneity of variance and multicollinearity across the sample was verified (see Supplementary Materials).

A preliminary analysis was executed on Instagram variables to exclude any effect of participants' gender (4 repeated measures, $\alpha = 0.0125$). An equivalent statistical procedure was adopted for Instagram variables overall for

¹1000 Genomes project, BioSample: SAMN07486024, dbSNP (Short Genetic Variations), 2017

Instagram Variables						
Variable	Min	1st Q	Median	Mean	3rd Q	Max
Posts Number	0.33	0.39	0.49	0.56	0.67	1.19
Followings Number	-1.54	-0.77	-0.12	-0.12	0.52	1.80
Followers Number	-0.80	-0.50	-0.16	-0.11	0.22	1.45
Social Desirability Index	-1.16	-0.28	-0.13	-0.16	-0.03	0.61
Parental Bonding Dimensions						
Variable	Min	1st Q	Median	Mean	3rd Q	Max
Maternal care	0.00	4.00	8.00	9.97	14.00	28.00
Paternal care	0.00	9.00	14.00	14.49	18.00	30.00
Maternal Overprotection	8.00	18.00	23.00	23.82	30.00	37.00
Paternal Overprotection	11.00	23.00	29.00	27.05	32.00	37.00

Table 1: Descriptive statistical summary of each variable: minimum (Min), first quartile (1st Q), median, mean, third quartile (3rd Q) and maximum (Max).

our hypothesis-driven analysis. Four multiple linear regressions were performed with the Instagram value as the dependent variable, the 5-HTT gene genotype rs25531 (T/T and C carriers) as a between-subjects factor and the PBI dimensions (i.e. maternal care, maternal overprotection, paternal care, and paternal overprotection) as continuous covariates. Hence, a Bonferroni correction was applied for the number of tests (4 repeated measures, $\alpha = 0.0125$). Post-hoc power analysis was calculated with *G*Power* software (version 3.1) [45]. One 2-way interaction effect was obtained and represented by a barplot and a scatterplot with linear models. Pearson’s r and Fisher’s z coefficients were used to estimate the effect of the covariate on the dependent variable, while R^2 and Cohen’s d were calculated to quantify the size of the significant effects.

For the significant interaction between the genotype and the PBI covariate on the Instagram variable, post-hoc Student’s t -tests (2 repeated measures, $\alpha = 0.025$) were performed within the low vs high PBI groups (obtained by the median split procedure) to prove differences between the two genetic clusters.

Results

Means and standard deviations of the measured variables are reported in Table 2.

Number of Posts				
PBI Dimension	Low/TT	Low/C	High/TT	High/C
Maternal Care	0.57 (0.05)	0.56 (0.07)	0.55 (0.05)	0.57 (0.12)
Paternal Care	0.56 (0.05)	0.50 (0.04)	0.57 (0.05)	0.64 (0.12)
Maternal Overprotection	0.57 (0.05)	0.63 (0.12)	0.56 (0.04)	0.50 (0.04)
Paternal Overprotection	0.57 (0.05)	0.65 (0.12)	0.55 (0.05)	0.51 (0.06)
Number of Followings				
PBI Dimension	Low/TT	Low/C	High/TT	High/C
Maternal Care	0.11 (0.19)	-0.27 (0.21)	-0.27 (0.17)	0.01 (0.75)
Paternal Care	-0.19 (0.17)	-0.60 (0.18)	0.01 (0.20)	0.28 (0.41)
Maternal Overprotection	-0.09 (0.19)	-0.034 (0.39)	-0.11 (0.18)	-0.33 (0.30)
Paternal Overprotection	-0.12 (0.16)	0.32 (0.34)	-0.06 (0.22)	-0.53 (0.28)
Number of Followers				
PBI Dimension	Low/TT	Low/C	High/TT	High/C
Maternal Care	-0.03 (0.13)	-0.19 (0.13)	-0.15(0.10)	-0.10 (0.38)
Paternal Care	-0.12 (0.11)	-0.29 (0.17)	-0.07 (0.11)	-0.02 (0.20)
Maternal Overprotection	-0.07 (0.12)	-0.15 (0.20)	-0.13 (0.10)	-0.17 (0.19)
Paternal Overprotection	-0.10 (0.11)	0.16 (0.22)	-0.09 (0.12)	-0.38 (0.13)
Social Desirability Index				
PBI Dimension	Low/TT	Low/C	High/TT	High/C
Maternal Care	-0.27 (0.08)	-0.19 (0.04)	-0.02 (0.05)	-0.34 (0.18)
Paternal Care	-0.21 (0.07)	-0.23 (0.08)	-0.05 (0.06)	-0.23 (0.08)
Maternal Overprotection	-0.11 (0.08)	-0.22 (0.09)	-0.16 (0.06)	-0.23 (0.07)
Paternal Overprotection	-0.14 (0.07)	-0.17 (0.06)	-0.13 (0.06)	-0.26 (0.08)

Table 2: Mean values in T/T homozygotes and C-carriers divided by PBI dimensions (high or low) on Instagram variables. Standard error means are reported between parentheses.

Instagram variables: Preliminary Results

Four two-tailed Student's t -tests were conducted (see Table 3) to exclude any influence of gender on Instagram variables. Only the number of followings was found to be higher in males than females ($t = 2.60$, $df = 55$, $p < 0.0125$). Consequently, participant gender was included as a between-subjects variable limited to the number of Instagram followings.

Instagram Interaction Effects

Social Desirability Index. Results of the regression analysis on the standardized SDI ($F(9,47) = 1.92$, $R^2 = 0.27$, power = 0.83) revealed a significant interaction between maternal care and genotype emerged for Instagram SDI

Instagram Variable	Males	Females
Posts Number	0.60 (0.05)	0.55 (0.03)
Followings Number	0.32 (0.23)	-0.30 (0.12)
Followers Number	0.08 (0.12)	-0.19 (0.08)
Social Desirability Index	-0.11 (0.03)	-0.18 (0.05)

Table 3: Mean values in male and female participants on Instagram variables. Standard error means are reported between parentheses.

($\beta = 0.04$, $SE = 0.01$, $t = 2.86$, $p < 0.006$). The distribution of genotypes TT vs C-carriers was not significantly different between high vs low maternal care ($X^2(1) = 2.46$, ns). No main effect of covariate, genotype or other interactions with genotype were significant. Maternal care was negatively associated with the Instagram SDI for C-carriers ($t(15) = -2.50$, $df = 13$, $r = -0.57$, $p < 0.03$), but positively associated with the Instagram SDI for T/T homozygous ($t(42) = 2.75$, $df = 40$, $r = 0.40$, $p < 0.01$) (Figure 1). A significant difference between the slopes for T/T and C-carriers was confirmed by Fisher’s z ($z = 3.24$, $p < 0.001$). Moreover, one-tailed post-hoc Student’s t tests on the C-carriers vs T/T in low and high maternal care groups revealed that the SDI was significantly different between C-carriers and T/T homozygotes only when they reported past experiences of high maternal care ($t = 2.30$, $df = 25$, $p < 0.025$), but not when they had a past of low maternal care ($t = -0.76$, $df = 28$, ns) (Figure 1). Homogeneity of variance of the SDI by maternal care was checked ($K^2 = 0.12$, $df = 1$, ns).

Number of Instagram Posts, Followings and Followers. No significant main effect or interactions were found.

Discussion

In this study, we probed how alleles in 5-HTT rs25531 interact with recalled parental care and overprotection in the modulation of social behaviour on Instagram. Specifically, we hypothesized one genotype*environment interaction (5-HTT rs25531 SNP * parental bonding in childhood) on Instagram variables.

In accordance with the hypothesis, we discovered that adult Instagram users with genetic vulnerability (T/T homozygotes) showed varying Instagram social conduct related to the quality of the parental practices experienced in childhood. As expected, T/T homozygotes who reported high maternal care

Figure 1: **A:** Effect of the interaction between genotype and maternal care on the standardized Instagram Social Desirability Index. Correlations between the Social Desirability Index and the reported maternal care. Black circles = C-carriers; grey circles = T/T homozygotes. Lines represent the linear models for C-carriers (black) and T/T homozygotes (grey). Pearson's r values are reported. **B:** Comparison between Social Desirability Index in C-carriers (black) and T/T homozygotes (grey) divided into high and low maternal care. (* $p < 0.025$)

scores exhibited an increasing trend in the Instagram SDI. In contrast, those who reported low scores in the equivalent dimension determined a decreasing trend in the same index. Interestingly, C-carriers showed the opposite pattern: as maternal care scores were lower, Instagram SDI increased. In particular, vulnerable genetic carriers (T/T homozygotes) with a positive relationship with the mother displayed a higher Instagram SDI than protective genetic carriers (C-carriers).

Our findings were consistent with previous results on 5-HTT and rs25531, which suggested a large variability between carriers in the behavioural response to social and distressing stimuli [46, 47, 22]. Elucidating the moderating role of the genotype on the sensitivity of the phenotype to environmental influences [24], the *differential susceptibility model* states that an individual can be more or less genetically susceptible to the beneficial versus dysfunctional effect generated respectively by enriching or undermining circumstances [13, 12]. This study investigated the present model on rs25531 within a novel and innovative framework: the online social behaviour on Instagram, an SNS. In line with the model [13], a T versus C allele's pres-

ence implicated a conditional variation in the online social response: T/T homozygotes who benefited from efficacious maternal care displayed a higher Instagram SDI than C-carriers. In this condition, Instagram users carrying the C allele were shown to be less susceptible than T/T homozygotes to supportive maternal care during childhood. Compared to T/T genotype, the C allele conferred lower vulnerability to adverse conditions linked to neglecting caregiving and less advantage from a favourable and positive relationship with the mother. As a consequence, users with the C allele exhibited an Instagram social response unconcerned about the advantages promoted by an appropriate maternal caring [48, 25]. Otherwise, users with the T/T genotype took advantage of a protective and comfortable maternal relationship, exhibiting higher asymmetry between the number of followers and followings than less sensitive ones [49]. As a result of developmental flexibility, the T allele predisposes individuals to be more vulnerable or plastic according to the functional or dysfunctional attachment with the mother [50, 51, 52].

The present research extends previous evidence of genetic influence on the frequency of online social behaviour [53, 54, 55]. Regarding 5-HTT rs25531, a previous study found that carriers of susceptibility genetic factors (T/T homozygotes) presented a higher Instagram number of followings than non-sensitive ones (C-carriers) when they reported a high level of confidence toward others [56]. As pointed out by another work [38], in the current study, users genetically susceptible to environmental influences displayed higher SDI when they have previously experienced positive maternal bonding.

We focused our attention on the SDI because it represents the distribution of contacts for each user on Instagram. This index attributes a size to the structure of each user's network, where the number of followers increased at the cost of the number of followings. Maximizing the SDI means enlarging the network structure to achieve greater approval and benefit from the masses [57, 58]. Within this frame, we argue that higher maternal care could determine the basis of new prosocial behaviour in the offline environment, later combined with a greater need for social desirability in the online environment [59, 9, 38]. An Instagram user sensitive to early experiences with the mother could, in turn, respond more efficaciously to the request of others and support social exchanges in response to their followers' expectations [60, 61, 43].

Conclusion

This research is not exempt from some limitations. Firstly, the low sample size was constrained by data collection of multiple variables in a fixed period. Moreover, data collection was circumscribed to young adults, and the participants' socioeconomic status (SES) was not evaluated. For instance, users who live in a situation of economic security could increase their Instagram activity to prove their ideal prosperity to the followers [62]. The year of the first registration on Instagram was also not collected; thus, the indexes' quantities were not controlled for the duration of online activity. Furthermore, the analysis was performed on no more than three Instagram parameters and one combined index that did not factor in "bot accounts" or "artificial" followers that can be purchased instead of being earned through social capital [63, 64]. Finally, the recalled parental bonding was measured with a self-reported instrument.

Future studies should consider a more extensive and multicultural sample to probe potential cross-cultural differences in Instagram behaviour and a gender-balanced sample that includes participants of different ages. The assessment of plausible moderators of Instagram usage like the SES and the sense of membership with peer groups may also be considered. The increase in the number of posts, followers and followings should be traced in relation to the year of the first registration on Instagram. Novel Instagram variables and indexes able to detect the variety of the shared content may also be taken into account, such as Instagram number of stories and tagged posts or the time spent using Instagram actively (i.e., chatting, posting) and passively (i.e., viewing, scrolling). To detect the long-term impact of early life, a longitudinal study to analyze the development of online social skills as an effect of genes and experiences is recommended. Furthermore, physiological measures from peripheral and central nervous systems could be adopted to discover potential differences between online and offline social responses. Finally, as rs25531 and 5-HTTLPR result in two independent loci for analysis [18], this model could be implemented on 5-HTTLPR.

In conclusion, serotonin transporter gene polymorphisms (rs25531) and early caregiving behaviours play an interactive role in the development of online social behavior in Instagram users. Combined with previous evidence, these results offer an active contribution to identifying an online social marker in the interplay between genetic and environmental components.

Ethics

The research was authorized by the Ethical Committee of Nanyang Technological University (IRB-2015-08-020-01). Informed consent was acquired from all participants, and the study was conducted following the Declaration of Helsinki. Questionnaires' data and Instagram data were anonymized at the beginning of the data collection. The genetic assessment was performed on anonymized biosamples at the Nanyang Technological University (Singapore).

Data Access

The data of this study can be found in the NTU's Data repository (DR-NTU Data) at the following address:
<https://doi.org/10.21979/N9/XIVRWS>

Authors Contribution

Conceptualization and Experimental Design: IC, GE, BL. Data Collection: IC. Data Curation: AB, GG. Genetic Analysis: MT, JNF. Data Analysis, Data Interpretation: AB. Writing: AB, IC. Revision: AB, BL, IC, GG, GE. Supervision: GE, BL.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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