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SNSs use in Generation Z, emotional stimuli processing, and its neural correlates. Evidence from the functional near-infrared spectroscopy[1,2]

Barbara Gawda[1[A,B,C,D,E,F]]
Małgorzata Chojak[2[A,B,C,D,E,F,G]]
Adrian Korniluk[1[A,B,C,D,E,G]]
[1] Department of Psychology of Emotion & Personality, University of Maria Curie- Sklodowska, Lublin, Poland
[2] Department of Didactics, Neuroeducation Research Laboratory, University of Maria Curie-Sklodowska, Lublin, Poland

SUMMARY

Background: The paper aims to examine the relationship between three factors among Generation Z members: time spent on SNSs (Social Network Sites) activities, visual vs. linguistic emotional stimuli processing, and neural activation during the performance of visual vs. verbal tasks. Although generation Z is described as having worse emotional linguistic competence than it does a visual competence, there is a lack of experimental research documenting these dissimilarities. The study involved a group of 57 adults born between 1995-2000, i.e. representatives of Generation Z.

Material/ Methods: The experiment consisted of two parts: the first devoted to the testing of emotion recognition from images (The Scale of Emotional Intelligence – Faces), and the second performing linguistic emotional tasks (The Emotion Understanding Test). During the tests a neuroimaging technique (functional near-infrared spectroscopy) was applied to examine and register neural cortical activity in the frontal, temporal, and occipital areas. The Social Network Sites Scale was used to assess the level of social network site use.

Results: Results showed that individuals representing Generation Z perform better in visual emotional task than in linguistic tasks. There is an association between SNSs use and brain activation.

Conclusions: Gen Z who overuse SNSs present greater activation of the brain regions responsible for a greater cognitive effort such as frontal and prefrontal areas. The activation differences in the frontal and temporal cortical regions between high users of SNSs and low users document the impact of SNSs utilization on brain functioning and confirm that SNSs overuse can have a negative impact on linguistic emotional stimuli processing.

Key words: image vs. linguistic processing, social network sites' use, neuroimaging evidence

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INTRODUCTION

The literature suggests that there are difficulties in emotional processing in digital native 2.0 generation (Generation Z/Gen Z). It is indicated that the reasons for these difficulties may result from growing up in the world of digital technologies. Digital natives 2.0 generation, otherwise known as generation Z, also known as the iGeneration, iGenners, Gen-Z, and Generation Now, consists of those born in the mid-1990s through the late 2010s. (Looper, 2011). According to some research, upbringing in a digital environment contributed to the fact that generation Z is more focused on perceptual/visual data than linguistic data, e.g. they have difficulty understanding the text (Liu et al., 2012). It has been suggested that Generation Z processes visual data better than verbal data. This is due to the frequent use of computer technologies, PCs, screens mobiles, and social networking sites, and even constant presence on them. The constant digital technology use that influenced Generation Z in college has caused this cohort to have different emotional competencies and visual attention. Statistics show that two-thirds of United States teens own an iPhone and that teens check their phones approximately 80 times per day (Twenge, 2017). Researchers believe that this activity modifies the emotional functioning of Gen Z because excessive contact with visual stimuli / online communication / indirect / and abuse of emoticons contributes to the reduction of language-based emotional communication and the impoverishment of emotional language (Krohn, 2004; Yuasa et al., 2011; El Mansouri et al. 2023). Thus, generation Z is described as using more visual perception than language/auditory perception and having some emotional problems associated with that (Prensky, 2001, 2005). The author of the generation concept, i.e. Prensky (2005), suggests in his essay that people from the digital generation have “different brains” than the older generations but he does not verify this thesis empirically.

Growing up with digital technological advances can have strengths. For instance, Gen Z is able to get news quickly and communicate efficiently with people around the world (Seemiller and Grace, 2016). Gen Z representatives prefer to communicate through social media (SNS, i.e. Social Network Sites) rather than face-to-face (Törőcsik et al., 2014). Facebook and other social platforms/applications make it possible for an individual to construct a socially desirable identity (Zhao et al., 2008) by creating one’s own profile, or by identifying with a group of persons described as friends (Boyd, Ellison, 2007). Meta-analyses indicate that the size of someone’s virtual social network increases until he/she reaches young adulthood; while afterward its gradual decrease can be observed (Wrzus et al., 2013). Being an extravert helps one’s to get more friends (Amichai-Hamburger and Vinitzky, 2010). Narcissistic persons who use SNS often try to make as many friends as possible.

On the other hand, SNS or digital technology use can be disadvantageous, when for example virtual replaces social interaction. Gen Z has a bond to digital media causing them to become emotionally attached to the internet (Turner, 2015). Facebook's use can have many emotional consequences such as feelings of loneliness and feelings of envy which can be detrimental to one achieving life satisfaction (Freeman et al., 2014). Social media may be a replacement for in-person contact. Having friends whom one does not know in person is related to having lower self-esteem in comparison with one's perception of others (Chou and Edge, 2012). Gen Z significantly more frequently treated Facebook as an inherent element of life and used Facebook to create virtual friends groups (Sitko-Dominik, 2019). However, data on the relationships between digital technology use and emotional functioning are ambiguous. For instance, virtual empathy has been found to positively correlate with live face-to-face empathy and people can show empathetic responses to others online (Carrier et al., 2015). Other research documented that being online, in general, had little negative influence on real-world and cognitive empathy (Carrier et al., 2015). Advanced technology use is positively associated with cognitive empathy and understanding of others' feelings, which appears to be high in Gen Z (Carré et al., 2013). In general, researchers believe that new technologies have become an inherent element of life among young adults which has an impact on their behavior, their expectations concerning education, and lifestyle (Arampazi et al., 2018; Howe and Strauss, 2000; Oblinger et al., 2005).

Image vs. language. Although Gen Z is described as performing better in visual perceptive than linguistic processing, the empirical evidence on these differences is sparse. Comparison of generation Y and Z attention revealed that the difference between text and image processing does not appear to be large. For instance, researchers found that the average fixation duration is not dependent on the age group (Gen Y and Gen Z). Furthermore, a higher fixation count within Gen Y (compared to Gen Z) indicated a higher cognitive load in Gen Y. Gen Z fixated on image stimuli fewer times on average than Gen Y, indicating their lower interest in image stimuli (Krajina, 2018). Gen Y spent more time interpreting image stimuli areas (Djamasbi et al., 2010). It is important to note that the researchers found differences between the age groups in terms of interface and design, however, not between generations but only of age. The important aspect that has been evaluated was the use of an image vs. no image. Researchers concluded that with a lower number of fixations on textual stimuli, Gen Z did prefer images and that Gen Z who read the text needed higher cognitive effort to process and interpret it, compared to Gen Y (Djamasbi et al., 2010; Krajina, 2018). Although some data confirm the differences between generation Z and others, there are no studies in the literature documenting the differences between the generations in the neural mechanisms of affective linguistic vs. visual information processing.

Therefore, we aim to examine putative differences in the neural mechanisms underlying the visual and linguistic emotional stimuli processing in Gen Z representatives. We focus on cortical activation in the frontal, temporal, and occipital areas during the processing of these two information types based on general data on brain correlates of processing emotional verbal, and visual information.

We also refer to some findings on brain alternation in people addicted to SNS (He et al., 2017). It has been found, for instance, that the grey matter volume in the amygdala is lower in people addicted to SNSs, and negatively associated with SNSs addiction scores. SNSs addiction seems to be associated with increased grey matter in the anterior cingulate cortex (ACC) and the midcingulate cortex (MCC) (He et al., 2017). Data on neural processing emotional linguistic and visual stimuli in general indicate several cortical regions involved in this because it engages perception, attention, memory, and other cognitive processes. First, occipital and temporal regions are highlighted. Emotional linguistic processing involves the primary and secondary visual cortex and the fusiform gyrus which are associated with explicit memory retrieval (Gabrieli et al., 1998; Gawda and Szepietowska, 2016). The primary and secondary occipital areas and temporal regions are activated during emotional information retrieval (Tabert et al., 2001). Negative emotional information encoding involves perceptual processing and engages occipital areas associated with the visual processing of emotional information (Dolcos et al., 2012). The middle temporal gyrus (which is thought to be responsible for semantic processing) (Birn et al., 2010) and the fusiform gyrus are also involved in semantic processing (Ardila et al., 2006). The frontal and prefrontal regions are also engaged in emotional linguistic and visual stimuli processing because they are responsible for attention, working memory, and executive functions involved in emotional processing (Goldberg et al., 2013; Robinson and Tamir, 2005). The right prefrontal cortex, for instance, is associated with episodic retrieval during tasks with emotional subjective evaluation (Schmitz et al., 2004). Greater activation of the frontal regions during verbal fluency tasks may reflect not-impaired attention, better working memory, and information processing (Britton et al., 2011; Gawda and Szepietowska, 2016; Hartley, Phelps, 2012). It was also shown that the inferior frontal gyrus was involved in phonological encoding, and evaluation of emotional meaning, and the bilateral orbitofrontal cortex was engaged in emotional language processing (Vuilleumier, 2005). Increased activity of the frontal regions suggests the use of more effective monitoring, selection, and control of cognitive processes (Shimamura, 2002). Furthermore, the superior medial frontal gyrus was found to be engaged in the generation and processing of emotional semantic information (Ethofer et al., 2006). Retrieval of words is also linked to the posterior areas such as the parietal and occipital regions associated with the visual-spatial processing of information, including the processing of emotional information (Dolcos et al., 2012). In general, emotional processing involves higher neural activity in the frontal regions as well as parietotemporal regions (Gawda i in., 2017). The research documented that other regions are also activated by emotional linguistic material: the putamen, nucleus accumbens (Cato et al., 2004; Crosson et al., 2002; Vuilleumier, 2005).

Hypotheses

This project focuses on the comparison of visual vs. linguistic emotional stimuli processing and the examination of neural mechanisms underlying this processing in Gen Z representatives. Our purpose is the description of the possible indication of different cortical activation in the frontal, temporal as well as occipital areas during the processing of these two information types.

The study aims to test the neural correlates of emotional visual information processing (recognizing the emotion expression in photos) and linguistic (identifying the appropriate emotion expressions based on verbal descriptions) in representatives of the Z generation (i.e. born in 1995-2000). It is planned to explore and describe these differences in the background of information processing as they have not yet been presented in empirical research. The project is focused on the processing of both types of affective information in the two groups of Gen Z representatives: 1) used SNSs to a very large extent, and 2) those who use SNSs to small extent. We aim to examine the relationship between three factors among the University students who are Generation Z members: time spent on SNSs activities, visual vs. linguistic emotional stimuli processing, and neural activation during the visual vs. verbal task performance.

We hypothesize that people representing generation Z perform better in visual emotional tasks than linguistic tasks. Their emotional competencies such as recognizing emotions and naming affective events are high; however, those competencies which are based on perceptive stimuli such as recognition of emotions are better than linguistic emotional competencies such as naming emotions. Then, based on the data on the association between SNSs use and brain activation as well as putative differences between linguistic emotional and visual emotional processing in Gen Z, we expect that SNSs overuse can differentiate emotional competencies and brain activation in persons from Gen Z. We expect the differences in activation of frontal, occipital, and temporal cortical regions between the groups, i.e. frequently SNSs use vs. low SNSs use.

MATERIAL AND METHODS[1]

Participants

The study aimed at adults born in 1995-2000, i.e. who can be classified as Gen Z. A sample of 57 persons was examined (46 women and 11 men). The invitation and study information was disseminated via social network sites and online discussion groups. The basis for inclusion was the data from the provided survey (i.e. the year of birth after 1995) and the participant's consent to participate in the experiment. Mean age = 23.6 (SD = 2.5). A mean number of education years was 13.8 (SD = 1.8). Another inclusion criterion was the lack of mental and physical impairments and willingness to complete the tasks. Persons who did not consent to the examination are excluded from the study as well as people who provided extreme answers, missing data, and/or did not comply with the

[1] All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional (University of Maria Curie-Sklodowska) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

commands contained in the instruction; people who reported taking medications affecting cognitive functions, people who have declared brain trauma or neurological (e.g. epilepsy) or mental diseases (e.g. depression, PTSD), and people declaring distraction and/or a particular lack of comfort. All included participants signed informed consent forms and received a debriefing sheet after completing the screening survey. The present study was approved by a local Ethics Committee of University of Maria Curie-Sklodowska (protocol no. 6/2021).

Procedure and Measures

Measures were obtained from three sources. First, participants were asked to complete a survey that captured their SNS use levels, demographics and descriptive variables, as well as inclusion-exclusion criteria. Second, participants completed screening criteria forms for capturing medical issues that may put individuals at risk in the NIRS cap as well as specific mental conditions and substance addictions that would exclude them from this study. These data were used for exclusion-inclusion decisions but not for hypothesis testing.

The research procedure began with a clause informing the potential respondent about the purpose, anonymity, and voluntary participation in the research.

1. The Social Network Sites (SNSs) Scale. The SNSs Usage questionnaire by Shi, Luo, Yang, Liu, and Cai (2014) is a self-report measure. The SNSs are defined as web-based services that allow individuals to construct a profile and share connections with a certain list of other users. In SNSs, people can establish their own social networks, design their own homepages, and post personal news, photos, audio, videos, and so on (Shi et al., 2014). The questionnaire includes two subscales, the SNSs Featured Usage Scale and the SNSs. In this study, we used the SNSs Featured Usage Scale subscale which consists of 13 questions on the frequency of the Internet and SNSs use. The respondents answer on a 7-point Likert scale, in which the answers are as follows: 1 means “never”, 2 – “once a year”, 3 – “once a month”, 4 – “once a week”, 5 – “several times a week”, 6 – “daily” and 7 – “several times a day”. The participant has to recall to what extent he/she uses the selected social networking sites. The SNSs Scale reliability is appropriate (Shi et al., 2014). Taking into consideration the total score, we divided our group into three subgroups: high scores i.e. frequently use SNSs; average scores, and with low scores. This categorical variable (high SNSs use vs. low SNSs use) was used subsequently in the statistical analyses.
2. The Emotion Understanding Test (TRE test). TRE is a Polish instrument developed by Matczak and Piekarska (2011). It measures the components of knowledge about emotions. These can be knowledge of emotion words, relationships between emotions, changes occurring when emotions intensify, and knowledge of emotion sources. They can be related to situational factors as well as one’s internal properties and states, which have a modifying effect on external factors (Matczak and Piekarska, 2011). All tasks were presented in a linguistic form. The participants were asked to choose an appropriate emo-

tional word i.e. label of emotion or feeling among the proposed answers. The whole test consists of 30 closed-ended linguistic/verbal tasks that are grouped into five parts. These tasks are scored on a scale from 0 to 1 – the maximum score is 30 points. The test allows for determining the overall level of emotion understanding. The reliability of the TRE is good; α = 0.80 (Matczak and Piekarska, 2011). We selected three tasks from the TRE for our experiment: order the emotional words in terms of the intensity, name the state opposite to the given emotion name, and indicate the name of the emotion that is an indispensable component of the described emotional event.

3. The Scale of Emotional Intelligence – Faces (SIE-T) by Anna Matczak, Joanna Piekarska and Elżbieta Studniarek (Matczak et al., 2005). The test allows determining the recognition of emotions presented in perceptive/visual form. Test material consists of 18 photographs of faces expressing eight positive emotional states (four of them are presented by a woman and four by a man) and 10 negative emotional states (five presented by a woman and a man). Every photograph is assigned a different set of six emotion names, both positive and negative. The participant is to decide whether the face visible in a given photograph is expressing mentioned emotions, and each time marks one of three possible answers: expresses, does not express, and it is difficult to say. The SIE-T total score is calculated by summing up the points obtained in all tasks, a total number of 108 (18 photos x 6 names assigned to each photo). The reliability of the test estimated using Cronbach's α was or exceeded the value of 0.77. We choose our experiment with three tasks from the SIE-T.
4. NIRS (functional near-infrared spectroscopy)

Cortical activity was measured using fNIRS with optodes located in the occipital, temporal, and frontal regions.

Procedure: hardware and probe design

NIRS is a neuroimaging technique that has been increasingly used in the study of cognitive functions based on the non-invasive measurement of hemodynamic changes in the cortical brain surface, where activated areas of the brain experience high metabolic demand, and increased oxygen absorption (Ferreri et al., 2014). This oxygen consumption leads to an initial reduction in the amount of oxygenated hemoglobin (HbO), followed by an increase in regional cerebral blood flow, which consequently raises the HbO concentration (Fekete et al., 2014). NIRS exploits the changing optical properties in cortical tissue by emitting near-infrared light into the cerebral cortex whereby it is absorbed, scattered, or reflected, and detecting the amount of light that is redirected back towards the skull (Irani et al., 2007). The emitter optodes emit light to the cortical tissue while the receiver optode detects the amount of light reflected. The level of oxygenation determines the absorptive properties of hemoglobin, with activated areas of the brain absorbing more light due to the higher O2Hb level (Fekete et al., 2014).

A 64-channel (32x32) fNIRScout system (NIRx Technology, Germany) was used to measure the relative change in HbO, consisting of 26 emitters and 26

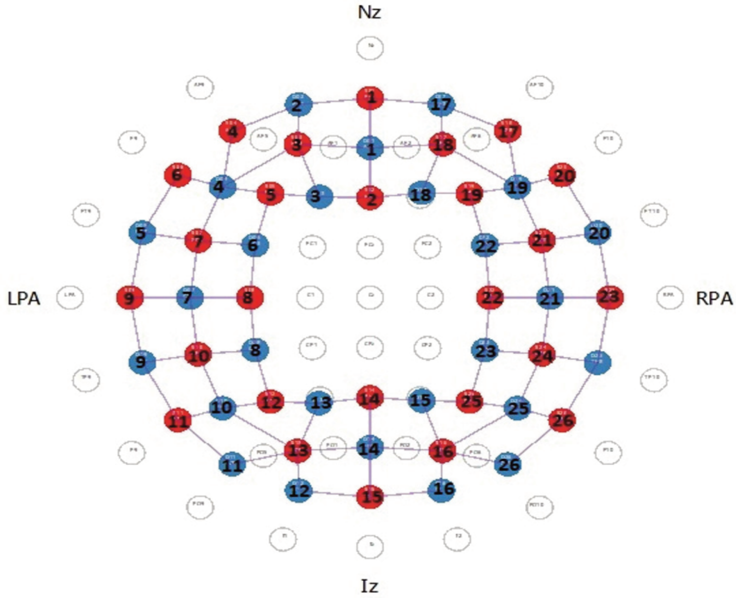

Fig. 1. Location of sources (red) and detectors (blue) on the surface 2D

detectors arranged in a standard 10x20 arrangement (diagram with description in Fig. 1). A total of 84 channels were obtained. Beta values were calculated in the bilateral prefrontal, temporal and occipital, and inferior parietal cortices at two wavelengths (750 and 850 nm). The exact location with reference to brain areas is shown in Table 1.

Procedure of examination

The brain activity recording protocol started with a 30-second recording, during which the subject kept his eyes closed and was instructed not to think about anything. The first task was to recognize emotions based on facial expression (3 tasks from the SIE-T Matczak, Piekarska, and Studniarek Test, 2005), and the second – to identify the appropriate expressions of emotions (3 tasks from the TRE Matczak and Piekarska test, 2011). While performing these tasks, the respondent sees the instruction for the task with the model stimulus material, then the board with picture 1, then the board with the answers to picture 1, then the board with picture 2, and then the board with the answers to picture 2, then the board with picture 3 and possible answers to this photo from the SIE-T test. After completing task 1, the subject was asked to look at the "+" on the screen for 20 seconds. (so-called REST in the study). Then, the subject sees a board with an instruction regarding the performance of the second task, i.e. indicating the opposite word naming emotions from the set (3 tasks of this type of task from the TRE test). After completing the 2nd task, the subject is asked again to stare at one point. After 20 seconds the subject is presented with the faces from task

Table 1. Location of emitters and detectors along with their corresponding areas of the brain

Dorsolateral prefrontal cortex							
	Source	Detector	Specificity (%)	Distance (mm)	X (mm)	Y (mm)	Z (mm)
S2-D18	Fz	F2	68.93306	29	10	41	50
S19-D18	F4	F2	68.36664	30	30	40	41
S3-D3	F3	F1	66.60628	29	-31	39	41
S2-D18	Fz	F1	63.16114	29	-9	41	50
S2-D1	Fz	AFz	61.76829	40	2	50	39
S17-D18	AF4	F2	51.52481	44	22	52	33
S3-D3	AF3	F1	48.43965	44	-23	52	32
S3-D6	F3	FC3	36.91972	36	-45	25	41
S19-D22	F4	FC4	30.71023	37	44	25	40
Frontopolar area							
S1-D1	Fpz	AFz	87.47713	40	1	64	14
S3-D1	AF3	AFz	75.76225	36	-12	62	23
S17-D1	AF4	AFz	72.46583	36	13	61	24
S3-D2	AF3	Fp1	69.63399	27	-24	63	9
S17-D17	AF4	Fp2	68.78125	28	25	63	9
S1-D2	Fpz	Fp1	54.49684	30	-12	67	0
S1-D17	Fpz	Fp2	54.45818	31	13	67	0
S18-D17	AF8	Fp2	31.08411	30	34	59	-2
Orbitofrontal area							
S1-D2	Fpz	Fp1	44.89777	30	-12	67	0
S1-D17	Fpz	Fp2	44.84703	31	13	67	0
S4-D2	AF7	Fp1	32.71174	30	-33	59	-2
S18-D17	AF8	Fp2	30.47282	30	34	59	-2
Primary Visual Cortex (BA 17 V1)							
S15-D12	OZ	O1	78.86259	30	-14	-101	-2
S15-D16	Oz	O2	67.60448	30	15	-99	-1
S15-D14	Oz	Poz	60.56278	40	-2	-97	12
S16-D16	PO4	O2	48.05182	28	26	-97	8
S13-D12	PO3	O1	40.65548	30	-26	-96	8
Visual Association Cortex (BA 18 V2)							
S16-D14	PO4	Poz	67.7951	36	16	-92	24
S13-D14	PO3	POz	64.83319	36	-16	-93	25
S13-D12	PO3	O1	48.61888	30	-26	-96	8
S16-D16	PO4	O2	45.9197	28	26	-97	8
S15-D14	Oz	POz	30.10278	40	-2	-97	12
Visual Association Cortex (BA 19 V3)							
S26-D26	P8	PO8	67.24002	30	48	-76	-6
S11-D11	P7	PO7	63.65472	30	-49	-74	-5
S14-D14	Pz	Poz	56.49581	30	-12	-83	42
Inferior Temporal gyrus							
S9-D9	T7	TP7	47.32283	30	-68	-32	-12
S23-D25	T8	TP8	41.51665	29	68	-31	-12
Middle Temporal gyrus							
S23-D20	T8	FT8	84.29994	31	66	-8	-12
S9-D5	T7	FT7	78.68913	30	-63	-9	-12
S23-D25	T8	TP8	54.95592	29	68	-31	-12
S9-D9	T7	TP7	49.28462	30	-68	-32	-12
S23-D21	T8	C6	38.01509	41	67	-19	4
S9-D7	T7	C5	37.01995	40	-65	-18	4
S24-D25	CP6	TP8	35.40248	39	65	-44	6
S10-D9	CP5	TP7	34.85068	38	-65	-44	5

Superior Temporal Gyrus							
S23-D21	T8	C6	47.32513	41	67	-19	4
S9-D7	T7	C5	42.20416	40	-65	-18	4
S24-D25	CP6	TP8	40.42588	39	65	-44	6
S10-D9	CP5	TP7	35.28858	38	-65	-44	5
S24-D21	CP6	C6	31.59862	33	65	-33	23
S10-D7	CP5	C5	30.59862	33	-65	-33	23
Fusiform gyrus							
S11-D9	P7	TP7	71.1953	30	-64	-52	-9
S26-D24	P8	P6	68.815	31	54	-67	6
S11-D10	P7	P5	68.55378	30	-54	-67	6
S26-D25	P8	TP8	68.10789	29	62	-52	-8
S11-D11	P7	PO7	31.51529	30	-49	-74	-5
S26-D26	P8	PO8	31.51529	30	49	-74	-5
Temporopolar area							
S20-D20	F8	FT8	31.95593	31	57	21	-4
S6-D5	F7	FT7	31.77477	30	-54	21	-4
Angular gyrus. part of Wernicke's area							
S25-D24	P4	P6	79.98991	30	47	-72	30
S12-D10	P3	P5	77.96924	30	-46	-72	30
S25-D23	P4	CP4	57.86556	35	46	-62	47
S12-D8	P3	CP3	53.29733	36	-46	-61	46
S24-D24	CP6	P6	34.98349	32	58	-58	22
S10-D10	CP5	P5	32.67053	32	-57	-57	21
Supramarginal gyrus part of Wernicke's area							
S24-D23	CP6	CP4	68.97636	38	58	-48	38
S10-D8	CP5	CP3	65.45949	38	-57	-48	38
S22-D23	C4	CP4	50.03508	36	53	-35	52
S8-D8	C3	CP3	43.31974	37	-52	-34	52
S12-D8	P3	CP3	29.76581	36	-46	-61	46
Subcentral area							
S21-D21	FC6	C6	49.06591	34	64	-5	22
S7-D7	FC5	C5	47.1287	33	-62	-3	23
Pars opercularis. part of Broca's area							
S7-D6	FC5	FC3	47.81345	36	-55	12	34
S21-D22	FC6	FC4	41.4546	36	56	12	33
S7-D4	FC5	F5	33.58711	33	-56	24	20
Pars triangularis Broca's area							
S6-D4	F7	F5	79.83606	28	-53	37	6
S5-D4	F3	F5	72.56408	29	-46	39	26
S19-D19	F4	F6	70.67254	30	46	38	24
S20-D19	F8	F6	65.82417	27	55	36	5
S7-D4	FC5	F5	53.07944	33	-56	24	20
S21-D19	FC6	F6	52.59098	34	58	24	18
S4-D4	AF7	F5	48.78624	33	-47	46	6
S18-D19	AF8	F6	43.87699	33	48	46	5
S3-D4	AF3	F5	32.1169	44	-39	50	17
S17-D19	AF4	F6	30.60393	45	40	50	16

1 again, but in a changed order, followed by REST, and then the subject performed task 2 again, with stimuli presented in a different order. After 20 seconds REST, the subject performed the modified tasks 1 and 2 again. The report ends in 20 seconds, and a record during which the subject's eyes are closed.

RESULTS

Behavioral data analysis

First, two groups (i.e. high and low SNSs) use have been defined based on the scores of the Social Network Sites Questionnaire. In the sample, we identified 11 persons who have low SNS scores (between 29.00 and 34.00) i.e. they declared low use of SNSs and 29 who have high scores (between 53.00 and 66.00) i.e. they declared high SNSs use. Maximum score in the SNSQ is 66.00 and minimum score is 29.00. Then, these two groups have been compared in terms of behavioral data (Table 2). We performed one-way variance analysis. These statistical analyses showed there are no significant differences between High vs. Low SNSs in the performance of the tasks from SIE-T and TRE tests, and no difference in the number of hours spent daily on the Internet. It means that people who spend a lot of time on SNSs do not differentiate in their recognition of emotions through mimic expression and naming of emotional situations from those who spend little time on SNS. Furthermore, these two groups do not differ in the number of hours spent on SNSs. Additionally, sex does not differentiate the scores in visual or linguistic emotional tasks.

The next step of the analysis was to compare intragroup scores i.e. differences between the performance of linguistic (TRE) and visual (SIE-T) tasks. We used t-test for one sample. This analysis revealed a significant difference between SIE-T and TRE performances. SIE-T is a measure of visual processing while TRE is a measure of linguistic processing. Gen Z performs better in visual tasks (SIE-T test) than in linguistic tasks (TRE test) (Table 3). The effect size for this difference is large (see Table 4).

The correlation between processing visual and linguistic stimuli is negative ($r = -.39$) which means that higher scores in visual/perceptive emotional stimuli processing are associated with lower scores in linguistic emotional stimuli processing.

NIRS data analysis

The next step of the analysis was to compare cortical activation between visual and linguistic emotional tasks and between the two groups i.e. high and low SNSs use. We performed a one-way analysis of variance to perform be-

Table 2. Descriptive statistics of two groups: high SNS use and low SNS use (N = 40)

Tasks		N	*M*	*SD*	*SE*	Min.	Max.	*F*(1,54)	*p*
SIE-T tasks	Low SNS	11	3.73	.60	.18	2.83	4.83	.464	.631
	High SNS	29	3.59	.53	.09	2.75	4.58		
TRE tasks	Low SNS	11	1.87	.82	.24	.67	3.33	.759	.473
	High SNS	29	2.14	.84	.15	.33	3.33		
Hours in SNS	Low SNS	11	3.90	1.81	.54	2.00	7.00	1.473	.238
	High SNS	29	3.81	1.86	.34	1.00	9.00		

SIE-T – Emotional Intelligence Scale – Faces, TRE – Test of emotions understanding, M – mean, SD – standard deviation, SE – standard error

Table 3. Performance of SIE-T and TRE. Intragroup comparisons (N = 57)

Tasks	***N***	***M***	***SD***	***SE***	**95% Confidence Interval of the Difference**		***t***	***p***
					Lower	**Upper**		
SIE-T tasks	57	3.66	.56	.07	1.23	1.85	10.15	.001
TRE tasks	57	2.13	.79	.10				

SIE-T – Emotional Intelligence Scale – Faces, TRE – Test of emotions understanding, M – mean, SD – standard deviation, SE – standard error

Table 4. Paired samples effect sizes

Paired Samples Effect Sizes						
			Standardizer	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	SIE-T task - TRE task	Cohen's d	1.14	1.34	.98	1.70
		Hedges' corr.	1.15	1.32	.96	1.67

tween-group comparisons and a t-test for dependent samples to calculate differences in cortical activation during visual vs. linguistic tasks.

Raw fNIRS data were recorded using NIRStar14.2 acquisition software (NIRx, Germany) and then processed using Homer3 analysis software. First, those participants with an incomplete record (e.g. not all conditions marked) were eliminated. Unrelated time intervals and motion-induced artifacts were eliminated during data pre-processing. In order to eliminate noisy signal, the qt-nirs algorithm in the Matlab R2019b environment was used (Montero-Hernandez, S., & Pollonini, L. QT-NIRS (Quality Testing of Near Infrared Scans) [Computer software]. https://github.com /lpollonini/qt-nirs), to remove channels with a signal-to-noise threshold below 73% (SCI=0.80, PSP=0.10). Therefore, the canals from the occipital area were not included in the statistical analyses. In the next step, people with a number of good channels below 35% (18 people) were eliminated.

Light intensities were converted to optical densities and blood oxygen concentrations using the modified Beer-Lambert law. The signal was also band-pass filtered, ranging from 0.01 to 0.5 Hz with hmrBandpassFiltr, to remove both noise and interfering signals (heart rate, respiratory rate, and Mayer waves). The initial hemodynamic response function (HRF) time was set to -2 s (i.e., baseline) and the end time to 20 s (i.e., single block task state). The data prepared in this way were exported in the .xlsx format to the SPSS 28 software.

Several Regions of Interest (ROI) have been taken into account such as prefrontal and frontal areas including the frontal eye area, BA 9, BA 10, and BA 11 of both hemispheres, occipital regions including primary visual cortex, secondary visual cortex, and BA 19. Then, temporal areas include the inferior temporal gyrus, middle temporal gyrus, superior temporal gyrus, fusiform and temporopolar gyrus, as well Wernicke's area and Broca's area. All regions are presented in Table 1.

The comparison between the two groups was performed with the U-Mann-Whitney test for independent samples as the data were not normally distributed.

Table 5. Comparisons of cortical activation between groups of high and low SNSs use in activation during image and linguistic tasks performance (U-Mann-Whitney test for independent sample)

Cortical areas (ROI)	SNSs	M	SD	SE	z	*p*
Image task						
Dorsolateral PC L	high	2.10	15.98	4.61	1.620	.061
	low	-8.08	9.35	3.30		
Dorsolateral PC R	high	-4.12	16.10	4.64	.259	.399
	low	-5.94	14.17	5.01		
Orbitofrontal C L	high	-1.15	22.31	6.44	.877	.196
	low	-9.11	15.31	5.41		
Orbitofrontal C R	high	-.82	20.83	6.01	1.845	.041*
	low	-16.27	13.57	4.79		
Frontopolar L	high	-2.24	13.59	3.92	.807	.215
	low	-6.81	10.23	3.61		
Frontopolar R	high	-1.31	13.10	3.78	2.135	.035*
	low	-11.24	7.65	2.70		
ITG L	high	-1.24	3.78	1.09	-.964	.174
	low	.42	3.81	1.35		
ITG R	high	.27	4.58	1.32	1.217	.120
	low	-2.38	5.10	1.80		
MTG L	high	-4.19	11.63	3.35	-1.08	.146
	low	2.21	14.67	5.18		
MTG R	high	-.14	16.62	4.79	1.121	.139
	low	-7.49	9.84	3.48		
STG L	high	-1.60	8.53	2.46	.349	.365
	low	-3.12	10.83	3.83		
STG R	high	-.38	12.16	3.51	.913	.187
	low	-4.55	4.97	1.75		
Wernicke's area	high	-4.98	22.32	6.44	1.234	.116
	low	-16.09	14.7	5.20		
Broca's area	high	4.90	25.57	7.38	1.281	.108
	low	-8.29	16.83	5.95		
Fusiform gyrus L	high	-1.36	10.24	2.95	3.15	.003*
	low	-13.17	2.91	1.03		
Fusiform gyrus R	high	2.20	11.88	3.43	.971	.172
	low	-2.58	8.83	3.12		
Temporopolar area L	high	-1.49	2.97	.85	-2.40	.014*
	low	2.43	4.35	1.53		
Temporopolar area R	high	-.97	3.18	.91	-1.56	.067
	low	1.15	2.61	.92		
Linguistic tasks						
Dorsolateral PC L	high	3.91	16.42	4.74	.591	.281
	low	-.413	15.36	5.43		
Dorsolateral PC R	high	7.15	21.01	6.06	1.221	.119
	low	-3.76	17.10	6.04		
Orbitofrontal C L	high	4.95	19.19	5.54	.335	.371
	low	1.58	25.91	9.16		
Orbitofrontal C R	high	2.89	24.12	6.96	.293	.387
	low	-.39	25.46	9.00		
Frontopolar L	high	.81	7.59	2.19	-.228	.411
	low	1.68	9.36	3.31		
Frontopolar R	high	.88	8.52	2.45	.250	.403
	low	-.14	9.77	3.45		

ITG L	high	-1.08	6.00	1.73	.815	.213
	low	-3.30	5.88	2.07		
ITG R	high	-.02	4.84	1.39	1.604	.051*
	low	-3.20	3.43	1.21	1.720	
MTG L	high	3.37	18.73	5.40	.805	.216
	low	-3.14	16.05	5.67	.832	
MTG R	high	-.67	13.80	3.98	.757	.229
	low	-4.92	9.38	3.31	.818	
STG L	high	2.43	14.17	4.09	1.145	.134
	low	-4.57	12.10	4.27	1.184	
STG R	high	-4.54	12.84	3.70	.424	.338
	low	-7.04	13.04	4.61	.423	
Wernicke's area	high	-.94	26.38	7.61	.734	.236
	low	-8.82	18.17	6.42	.791	
Broca's area	high	8.52	17.42	5.03	.541	.298
	low	3.45	24.62	8.70	.504	
Fusiform gyrus L	high	2.15	11.37	3.28	1.152	.132
	low	-4.78	15.66	5.53	1.079	
Fusiform gyrus R	high	1.66	10.37	2.99	.522	.304
	low	-.82	10.53	3.72	.521	
Temporopolar area L	high	1.16	5.23	1.51	1.646	.05*
	low	-3.04	6.14	2.17	1.592	
Temporopolar area R	high	-1.11	5.02	1.45	-.773	.225
	low	.55	4.26	1.50	-.800	

*p<.05 M-mean, SD-standard deviation, SE –standard error, SNSs – Social Network Sites, ITG – inferior temporal gyrus, MTG, middle temporal gyrus, STG, superior temporal gyrus, L – left hemisphere, R – right hemisphere of the brain

The comparisons of high and low SNSs use revealed that there is a significant difference in cortical activation during image task performance in the right prefrontal (orbitofrontal and frontopolar) areas, left fusiform gyrus, and left temporopolar areas (see Table 5). People who frequently use SNSs present higher activation in the prefrontal areas which means that the emotional image is more difficult for them than those who use SNSs less frequently. Recognition of emotions from images was associated with greater activation in the prefrontal and temporal area among those using SNSs often. Also, two groups were compared in terms of activation during linguistic emotional task performance (Table 5). Only two significant differences in cortical activation have been observed: in the right inferior temporal gyrus and left temporopolar area (BA 38). Other regions were similarly activated in people with high and low SNSs use.

The next step of NIRS data analysis was to compare cortical activation between image and linguistic emotional tasks. A Wilcoxon test for one dependent sample was applied (distribution of the data was not normal). The results of this comparison showed that for Gen Z linguistic tasks were more demanding than image tasks. They presented greater activation in many areas such as left and right frontopolar regions and right orbitofrontal areas than during the image task performance. Linguistic tasks also involved a greater activation in temporal areas, particularly in the superior temporal gyrus of the left and right hemispheres. Additionally, these tasks involved Broca's area, which is the site for lin-

Table 1. Location of emitters and detectors along with their corresponding areas of the brain

				95% CI for the difference			
Image – Linguistic task	**M**	**SD**	**SE**	**CI Lower**	**CI Upper**	**z**	**p**
Dorsolateral prefrontal L	-2.77	16.71	3.15	-9.25	3.70	-.878	.194
Dorsolateral prefrontal R	-4.25	19.44	3.67	-11.79	3.28	-1.158	.129
Frontopolar L	-5.78	12.19	2.30	-10.50	-1.05	-2.510	.009**
Frontopolar R	-7.61	17.06	3.22	-14.23	-.99	-2.361	.013*
Orbitofrontal L	-1.98	8.02	1.51	-5.10	1.12	-1.310	.101
Orbitofrontal R	-3.15	9.51	1.79	-6.84	.53	-1.757	.045*
BA20 L	1.01	6.04	1.14	-1.33	3.35	.888	.191
BA20 R	.38	6.28	1.18	-2.05	2.82	.323	.374
BA 21 L	.27	17.93	3.39	-6.68	7.22	.080	.468
BA21 R	.52	15.05	2.84	-5.31	6.36	.185	.427
BA 22 L	-4.59	12.01	2.26	-.06	9.25	-2.025	.026*
BA 22 R	-5.82	14.01	2.65	.36	11.25	2.18	.01**
Wernicke's area	-.20	22.55	4.26	-8.94	8.54	-.047	.481
Broca's area	-6.74	20.93	3.95	-14.86	1.37	-1.704	.050*
Fusiform gyrus L	-2.77	13.31	2.51	-7.93	2.39	-1.102	.140
Fusiform gyrus R	-1.03	11.85	2.24	-5.62	3.56	-.460	.324
Temporopolar area L	1.20	5.61	1.06	-.97	3.38	1.133	.134
Temporopolar area R	-.08	4.65	.87	-1.89	1.71	-.100	.460

**p*<.05, ***p*<.01, M-mean, SD-standard deviation, SE –standard error

guistic production. Significant greater activation in several cortical areas indicates that linguistic emotional tasks require Gen Z higher cognitive effort.

DISCUSSION

The results of our research showed that emotional competencies such as emotion recognition from the picture and naming affective events are at a good level in Gen Z. However, emotion recognition from images was performed better than linguistic tasks such as ordering emotional words in terms of their emotional intensity, naming the state opposite to a given emotion name, indicating emotion name that is an indispensable component of a described emotional event. All linguistic tasks were performed worse than visual tasks. The next important result refers to the differences between Gen Z who use SNSs to a large degree and those who use SNSs to a small extent. We found that frequent SNSs users do not differ in their performance in emotional tests, but they differ in cortical activation during test performance. Gens Z of high SNSs use had greater activation during image tasks performance in right prefrontal (orbitofrontal and frontopolar) areas, left fusiform gyrus, and left temporopolar areas and during linguistic tasks performance greater activation in right inferior temporal gyrus and left temporopolar area was observed. Our third important result refers to comparisons of cortical activation between image and linguistic performance in Gen Z. We showed that there are significant differences in left and right frontopolar regions, right orbitofrontal areas, temporal areas (superior temporal gyrus of left and right hemispheres) and Broca's area.

Our results are consistent with findings indicating that Gen Z is better in performing visual tasks than linguistic ones (Djamasbi et al., 2010; Krajina, 2018). They recognize images presenting emotional states better than a linguistic description of affective states/events. They performed the linguistic emotional tasks worse. This difference can be related to the frequent use of computer technologies, PC, screens or mobiles and so on. This is in line with findings showing that Gen Z presented a lower number of fixations on textual stimuli, and while reading the text they need higher cognitive effort to process and interpret it (Djamasbi et al., 2010; Krajina, 2018). Worse performance in linguistic emotional tasks can be associated with the frequent use of virtual technology which replaces social interactions. Gens Z is connected to digital media, they are emotionally attached to the SNSs which presents dominance of image over language (Turner, 2015). Social media may replace in-person contact and thus, can have an impact on worse emotional language development (Liu et al., 2012). Gens Z more frequently treated Facebook and other SNSs and an inherent element of their life, a decrease in face-to-face communication and relationships can influence linguistic emotional skills such as naming emotions, ranging emotion words, comparing emotion labels (Carier et al., 2015; Gawda et al., 2020).

Our findings showed that although there were no significant differences in behavioral data between high and low SNSs users, there were differences in the NIRS data, i.e. cortical activation. It suggests that different neural mechanisms may be involved in emotional processes, yielding similar behavioral effects. These results indicate a relationship between the task difficulty and the differences in brain activity in the high SNSs and low SNS users: the easier the task, the lower the differences in activation between the groups. People who use SNSs frequently present higher activation in prefrontal and temporal areas during image processing which means that emotional image processing is more difficult for them than for low SNSs users. Greater activation of prefrontal and temporal areas is linked to a greater cognitive effort among high SNSs users. Particularly difficult for them are linguistic tasks. It was confirmed by greater involvement of the inferior temporal gyrus and temporopolar areas during the performance. This is consistent with the data on the association between SNSs use and brain activation indicating that SNSs overutilization can differentiate brain activation (He et al., 2017). It also supports the thesis that high SNS users differ in information processing between more complex and less complex tasks, and these differences are reflected in neural mechanisms (Ralph, 2014). SNSs overuse results in some difficulties in emotional competencies, and thus, the performance of such tasks became more difficult for these persons from Gen Z. It shows that high SNSs use can have a negative impact on emotional stimuli processing.

Our results confirmed that linguistic emotional tasks were more difficult for Gen Z than image tasks. Many significant differences in cortical activation have been observed. Regions more involved in the linguistic task are typically related to language processing and associated cognitive effort. The prefrontal cortex is thought to be associated with episodic retrieval during tasks with emotional subjective evaluation (Schmitz et al., 2004). The orbitofrontal cortex was engaged in emotional language processing (Vuilleumier, 2005). Greater activation of the frontal regions during linguistic emotional tasks performance can reflect greater cognitive effort in Gen Z, i.e., involvement of attention, working memory, and information processing (Hartley and Phelps, 2012). These can be associated with increased processes of monitoring, selection, and control (Shimamura, 2002). Temporal regions were also more active during linguistic task performance which is typical for language processing.

The superior temporal gyrus involves complex language and auditory processing. Broca's area is responsible for binding elements of language, selecting information, sequencing, cognitive control mechanisms for the syntactic processing of sentences, and construction of complex sentences and speech patterns (Cato et al., 2004). Other differences have been found in the activation of the occipitotemporal area, i.e., fusiform gyrus which is largely involved in semantic processing, facial and body as well as word and number recognition (Dolcos et al., 2012). All these regions were greatly activated during linguistic tasks performance in Gen Z confirming that linguistic emotional tasks were more challenging for them. It shows that linguistic tasks are less familiar to them. To sum up, we can conclude that for Gen Z all linguistic emotional tasks were more difficult than image tasks and that it supports opinions about emotional language impoverishment in Gen Z (Krohn, 2004).

LIMITATIONS

Our study is not free of limitations. The limitation of this study was a potential factor influencing the sex differences. We included 46 women and 11 men in our study. The examination is time-consuming and a total sample is not of small size, however, an unequal number of women and men can have an impact on the findings. The results should be, however, interpreted with caution because of potential not-included factors.

CONCLUSIONS

The study examined the relation between three factors among Gen Z members: time spent on SNSs activities, processing of the visual vs. linguistic emotional stimuli, and neural activation during the visual vs. verbal task performance. We confirmed almost all our hypotheses. We found that Gen Z performs better in visual emotional tasks than in linguistic tasks. Emotional competencies such as recognition of emotions from pictures and naming affective events differ in Gen Z. They present better competencies based on visual stimuli processing than on linguistic emotional stimuli such as naming emotions. We confirm that there is an association between SNSs use and brain activation. Gen Z who overuse SNSs present greater activation in brain regions responsible for cognitive effort such as frontal and prefrontal areas. Gen Z can display problems in linguistic emotional processing which is in line with opinions that Gen Z displays worse emotional language development. We confirmed that SNSs overuse can differentiate emotional competencies and brain activation. The differences in activation of frontal and temporal cortical regions between high and low SNSs users document the impact of SNSs utilization on brain functioning.

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Corresponding author
Barbara Gawda
Institute of Psychology, University of Maria Curie–Skłodowska,
ul. Głęboka 45, 20-612 Lublin, Poland
e-mail: bgawda@wp.pl