HHS Public Access
Author manuscript
Soc Neurosci. Author manuscript; available in PMC 2017 December 01.

Published in final edited form as:
Soc Neurosci. 2016 December ; 11(6): 637–651. doi:10.1080/17470919.2015.1123181.

Computer-Mediated Communication Preferences and Individual Differences in Neurocognitive Measures of Emotional Attention Capture, Reactivity and Regulation

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Abstract

The use of computer-mediated communication (CMC) to engage socially has become increasingly prevalent, yet few studies examined individual differences that may shed light on implications of CMC for adjustment. The current study examined neurocognitive individual differences associated with preferences to use technology in relation to social-emotional outcomes. In Study 1 (*N*=91), a self-report measure, the Social Media Communication Questionnaire (SMCQ), was evaluated as an assessment of preferences for communicating positive and negative emotions on a scale ranging from purely via CMC to purely face-to-face. In Study 2, SMCQ preferences were examined in relation to event-related potentials (ERPs) associated with early emotional attention capture and reactivity (the frontal N1) and later sustained emotional processing and regulation [the late positive potential (LPP)]. Electroencephalography (EEG) was recorded while 22 participants passively viewed emotional and neutral pictures and completed an emotion regulation task with instructions to increase, decrease or maintain their emotional responses. A greater preference for CMC was associated with reduced size of and satisfaction with social support, greater early (N1) attention capture by emotional stimuli, and reduced LPP amplitudes to unpleasant stimuli in the increase emotion regulatory task. These findings are discussed in the context of possible emotion- and social-regulatory functions of CMC.

Keywords

computer-mediated communication; event-related potentials; emotion

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The immense popularity of computer-mediated communication (CMC) tools such as texting and social networking sites like Facebook have transformed the nature of our social interactions. Using CMC, we can accomplish many key social-emotional goals, such as expressing one's emotions, seeking or giving support, building and maintaining relationships, and alleviating loneliness (Fox, Warber, & Makstaller, 2013). Yet, research concerning the psychological and interpersonal impact of CMC is scarce and often

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contradictory. At the beginning of the new millennium, a wave of research on CMC emphasized its potential to detract from our psychosocial health, such as increasing loneliness and depression (e.g. Kraut et al., 1998). One hypothesis was that people who are more psychosocially distressed and socially-isolated prefer CMC (Caplan, 2003), in part because it is perceived as a less emotionally-risky alternative to face-to-face interactions (Bargh & McKenna, 2004; Madell & Muncer, 2007; McKenna & Bargh, 1999, 2000). Previous research has suggested that this preference may serve to reinforce psychosocial distress and maladaptive patterns of social interaction (e.g. Caplan, 2003; Walther, 1996, 2007) such as increases in depression and loneliness (e.g. Stepanikova, Nie, & He, 2010) and neglect of existing close relationships (Kraut et al., 1998; Nie, 2001).

In contrast, following this early wave of research, empirical evidence documenting an array of benefits associated with CMC has emerged (e.g. Kraut et al., 2002). For example, greater use of CMC has been correlated with *more* time spent face-to-face with family and friends (Kraut et al., 2002), greater involvement in off-line activities (Kirschner & Karpinski, 2010), and greater extraversion (Ross et al., 2009). Thus, particularly with the increasing accessibility and pervasiveness of CMC in our daily lives (e.g. Caplan, 2003), CMC may reflect normative ways of communicating and meeting social-emotional needs (Kraut et al., 2002; McKenna & Bargh, 2000; Shaw & Gant, 2002) and support adaptive efforts to increase positive social interactions and form meaningful interpersonal relationships (McKenna, Green, & Gleason, 2002).

Yet, several methodological issues complicate the interpretation of previous studies. First, previous studies relied upon broad self-report measures of CMC (e.g., hours of CMC use/week) instead of measures that reflect preferences and goals of CMC use, which may have more direct relevance for social-emotional functioning (Carpenter, 2012; DeAndrea & Walther, 2011) and can be used to characterize individual differences in specific patterns of CMC use. Second, while it is crucially important to examine links between CMC use or preferences and individual differences in social-emotional communication, understanding the nature of these associations requires assessment of related affective-cognitive mechanisms.

To address these methodological issues, Study 1 assessed a measure of *preference* for communicating emotions either face-to-face versus via CMC. First, participants were asked about the time they spend engaging in CMC or face-to-face interactions, as well as their preferences for communicating various positive and negative emotions or affective experiences on a spectrum ranging from purely face-to-face contexts (i.e. talking in person in real time, video chats) to purely CMC context (i.e. text messages, Facebook status updates).Thus, CMC versus face-to-face preferences were quantified in specific social-emotional communication contexts. Specifically, the SMCQ is intended to identify key individual differences in patterns of preferences for communication via CMC versus face-to-face interactions. We further examined associations between this self-report measure and patterns of CMC use (a Facebook Browsing Task) to provide converging evidence that the questionnaire captures individual differences that vary with specific patterns of CMC use.

In Study 2, neurocognitive indices of emotional attention capture and regulation were measured, in particular those that have been targeted as mechanisms underlying social-emotional well-being (e.g. DeCicco, Solomon, & Dennis, 2012; Groen, Wijers, Tucha, & Althaus, 2013; MacNamara & Hajcak, 2009). We leveraged the use of scalp-recorded event-related potentials (ERPs) because of their excellent temporal resolution, allowing for examination of both relatively early and automatic emotional attention capture and reactivity, and later-emerging, more effortful regulation of emotional responses. Thus, the sensitivity and specificity of ERPs allow for the precise measurement of the time-course of emotional processing associated with CMC preferences. The current study examined two ERPs: the N1 and the late positive potential (LPP).

The frontal N1 is an early, rapid, negative ERP that is maximal at approximately 100-150 ms post-stimulus onset at frontal and central recording sites (Lithari et al., 2010). This early negativity is thought to reflect automatic attentional capture of emotional compared to neutral images (Cuthbert, Schupp, Bradley, McManis, & Lang, 1998; Keil et al., 2002; Keil et al., 2001; Lithari et al., 2010; Olofsson, Nordin, Sequeira, & Polich, 2008), and is distinct from later cognitive components associated with emotional processing. N1 amplitudes are also greater in response to highly arousing emotional images compared to less-arousing emotional images (Keil et al., 2001; Lithari et al., 2010). The N1 (N110) also has been specifically associated with social-emotional processes related to subjective emotional reactivity. For example, recent research has indicated that N1 amplitudes are more positive when participants view images depicting others in pain versus non-painful stimuli (Decety, Yang, & Cheng, 2010; Fan & Han, 2008; Mella, Studer, Gilet, & Labouvie-Vief, 2012; Meng et al., 2012) and N1 amplitudes are correlated with subjective experiences of unpleasantness and magnitude of perceived pain (Fan & Han, 2008). Based on this body of research, the current study targeted the N1 to examine rapid attentional capture by emotional information, suggestive of greater subjective reactivity, in relation to patterns of CMC preferences.

The LPP is a slow-going positive waveform that emerges around 200 to 300 ms following the presentation of a stimulus and is sustained throughout and even following stimulus presentation (Hajcak & Olvet, 2008). The LPP is thought to reflect sustained attention and detailed processing of motivationally-salient and emotionally-evocative stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). LPP amplitudes are of greater magnitude to arousing pleasant and unpleasant stimuli as compared to neutral stimuli (e.g. Cuthbert et al., 2000; Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006), and subjective reports of greater emotional arousal are associated with greater LPP amplitudes (Cuthbert et al., 2000). Furthermore, when individuals are asked to flexibly modulate their emotional responses to stimuli, LPP amplitudes reflect these changes. For example, when participants are asked to engage in cognitive reappraisal by re-interpreting the meaning of an unpleasant image in a more positive way, LPP amplitudes are reduced in adults (Foti & Hajcak, 2008; MacNamara, Ochsner, & Hajcak, 2011) and children (DeCicco, O'Toole, & Dennis, 2014; Dennis & Hajcak, 2009; Hajcak & Dennis, 2009; Moser, Hajcak, Bukay, & Simons, 2006), suggesting that the LPP may have utility as a neural indicator of emotion regulation capacity (Babkirk, Rios, & Dennis, 2014). Furthermore, the LPP also reflects emotional flexibility when participants are asked to increase their emotional responses to unpleasant stimuli (Moser, Most, & Simons, 2010), or decrease their responses to pleasant stimuli (Hajcak, Moser, & Simons, 2006). In addition, the LPP is sensitive to individual differences in well-being, specifically anxiety and depression. For example, children with greater anxious-depressed symptoms show reduced ability to flexibly modulate emotional responses during a directed reappraisal task, as indicated by the LPP (DeCicco et al., 2012; DeCicco et al., 2014; Dennis & Hajcak, 2009). In both children and adults, greater LPP amplitudes to unpleasant compared to neutral stimuli is associated with greater anxiety (DeCicco et al., 2012; DeCicco et al., 2014; MacNamara & Hajcak, 2009). Thus, the current study targets the LPP as a neural indicator of individual differences in sustained reactivity to arousing emotional stimuli (in contrast to the N1, which reflects relatively early and brief emotional attention and reactivity), and as an indicator of regulatory flexibility.

In Study 1, we examined whether the SMCQ has internally-consistent subscales reflecting CMC preferences for a range of social-communication goals. Next, Study 2 took as a starting point the assumption that if CMC functions as a method through which social-emotional communication is facilitated when face-to-face communication is perceived as challenging or when social support satisfaction is low, then the following associations would be expected to emerge: Greater preference for CMC versus face-to-face communication will be associated with: (a) decreased quality and satisfaction with social support networks (b) greater amplitude N1 and LPP during a passive viewing (PV) task, indicating increased attention capture by emotional images; and (c) blunted ability to intentionally increase or decrease emotional responses to emotional stimuli as measured via the LPP in a cognitive reappraisal (CR) task, suggesting reduced regulatory flexibility. Study 2 included an assessment of social media behavior (a Facebook Browsing Task) in order to assess whether the CMC questionnaire captured individual differences associated with specific patterns of CMC use.

Study 1

Method

Participants—Ninety-one adults (66 females, 25 males), aged 18 to 32 years ($M = 19.1$, $SD = 2.5$), participated in Study 1. Participants were recruited through the psychology participant research pool at Hunter College, the City University of New York. Self-reported race/ethnicity was: 7 (7.7%) African-American, 13 (14.3%) Hispanic, 25 (27.5%) Caucasian, 32 (35.2%) Asian, 2 (2.2%) Pacific Islander, and 12 (13.2%) other.

Materials and Procedure

Social Media and Communication Questionnaire: After giving informed consent, participants completed the Social Media and Communication Questionnaire (SMCQ) as part of a larger study. The SMCQ is a newly-developed research tool that assesses participants' preferences in accomplishing specific active social communication goals via CMC (e.g. Facebook updates, text messages, blogging) relative to real time face-to face communication (a category that includes dual-participant video chat but excludes voice-only phone calls). In a pencil-and-paper questionnaire, participants were asked to recall their communication preferences over the past six months for 27 different categories of communication (e.g., sharing anger or boredom, feeling scared, asking for information, etc.) and to report those preferences on a Likert-like scale for each communication category (1 = Only CMC & Never Face-to-face communication, 7 = Never CMC & Only Face to-face communication). These data revealed a richly-detailed portrait of the individual communication preferences of each participant. The data captured by the SMCQ were then analyzed by means of a principal component analysis (varimax rotation with Kaiser normalization) in order to group communication categories with highly-correlated CMC or face-to-face preferences into relevant subscales for further investigation.

Beck Depression Inventory: The Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996) was used to assess symptoms of depression in study participants on a 0-63 point scale. Scores below 17 indicated a lack of clinical depression, while scores between 17 and 20 indicated borderline clinical depression and scores over 20 indicated clinical depression of increasing severity. BDI scores were correlated with SMCQ scores (discussed below) to determine whether a relationship between the two scores existed in the participant data.

Difficulties in Emotion Regulation Scale: The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) is a 36-item self-report questionnaire designed to assess aspects of emotion dysregulation on six subscales, including non-acceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. Participants responded to each of 36 statements about their personal regulation of emotion on a 1 (almost-never) to 5 (almost-always) scale. In this study, data from the questionnaire were compared against SMCQ results to determine if certain aspects of emotional dysregulation were common to participants' reported CMC preferences.

Results

Principal Component Analysis of the SMCQ—Prior to conducting a principal component analysis (PCA), the data were examined for their suitability for the technique. Bartlett's Test of Sphericity yielded a significant result [χ^2 (351) = 1065.873, $p < 0.001$], as did the Kaiser-Meyer-Olin Measure of sampling adequacy (KMO = .773), indicating that the degree of response overlap and the size of the sample were both sufficiently large to support the use of PCA. Criteria used for the identification of individual components were (1) eigenvalues greater than 1, and (2) factor loadings higher than .500. An initial exploratory factor analysis (EFA) was conducted using half of the sample, selected by random ($n = 48$).[1] The EFA yielded seven possible components, but of those seven, only three components were conceptually meaningful. A confirmatory factor analysis (**CFA)** was then run on those three components, using the remaining randomly-selected half of the participants ($n = 49$).[2] SMCQ subscales identified by the confirmatory PCA were as follows: (1) positive social communication (e.g., chat with friends, get to know people, keep in touch with people) (α = .**78**), (2) expressing distress (e.g., communicate worry, seek emotional support, have a

[1]For this split-half subsample, Bartlett's Test of Sphericity yielded a significant result [χ^2 (351) = 667.173, $p < 0.001$], as did the Kaiser-Meyer-Olin Measure of sampling adequacy (KMO = .607).
[2]For this split-half subsample, Bartlett's Test of Sphericity yielded a significant result [χ^2 (190) = 467.359, $p < 0.001$], as did the Kaiser-Meyer-Olin Measure of sampling adequacy (KMO = .760).

disagreement) (α = .**87**), and (3) casual communication (e.g., offer advice, communicate interest, communicate boredom) (α = .70). The appendix includes a list of the SMCQ factors that were included in each of the three subscales.

The SMCQ and Emotional Adjustment Measures—Two of the CMC preference scales were significantly correlated with depressive symptoms: A CMC versus face-to-face preference for expressing distress, [$r(91) = \mathbf{-.296}$, $p = \mathbf{.004}$] and casual communication [$r(91) = \mathbf{-.234}$, $p = \mathbf{.03}$] were associated with greater levels of depressive symptoms. In addition, SMCQ scores were related to difficulties in emotion regulation. Specifically, a CMC preference for casual communication was associated with greater difficulties engaging in goal-directed behavior [$r(91) = -\mathbf{.246}$, $p = \mathbf{.02}$], greater non-acceptance of emotional responses [$r(91) = -.\mathbf{202}$, $p = \mathbf{.05}$], and greater lack of emotional clarity [$r(91) = \mathbf{-.284}$, $p = \mathbf{.01}$]. A CMC preference for expressing distress was also associated with a greater lack of emotional clarity [$r(91) = \mathbf{-.243}$, $p = \mathbf{.02}$]. A CMC preference for positive social communication was not significantly correlated with emotional adjustment measures.

Discussion

The principal component analyses revealed three distinct and internally consistent subscales: positive social communication, expressing distress, and casual communication. These domains likely capture distinct and meaningful aspects of CMC communication preferences. Specifically, a crucial question left unanswered by these previous studies is whether all types of active CMC are associated with adaptive social-emotional functioning or if this association depends upon individual differences in patterns of CMC use. An emerging model of interpersonal communication and well-being argues that the social sharing of positive events, termed capitalization (Gable & Reis, 2010), has psychosocial benefits, such as increased positive emotion, greater satisfaction with social support, and decreased loneliness, when others respond in an active and constructive manner. In addition, it is possible that using CMC to express negative experiences and emotions may reap psychological benefits similar to that found for expressive writing, such as reduced mood problems (Lepore, 1997; Sloan & Marx, 2004), and greater satisfaction with social support (Baker & Moore, 2008). The findings of the current study suggest that preferences to use CMC for all types of emotions measured are associated with greater depressive symptoms, and a CMC preference for casual communication and expressing distress are related to greater difficulties with emotion regulation. One possible interpretation of these findings is that CMC use may serve as a tool through which certain individuals can manage negative emotional experiences when other strategies are not sufficient. This is consistent with the idea that expressing negative emotions via CMC may also enhance opportunities for the social regulation of emotion by eliciting support and engagement from others, through a constantly accessible medium, and reducing the detrimental impact of expressing negative emotions during face-to-face interactions (Lakey, Tardiff, & Drew, 1994).

In contrast, using CMC to share positive experiences or achieve positive communication goals (like staying in touch) may elicit little social support for emotion regulation because social-emotional feedback may lack immediacy and be relatively “impoverished” (i.e., no facial or vocal cues for positive social responses) (McKenna & Bargh, 2000; Seltzer, Prososki, Ziegler, & Pollak, 2012). Moreover, using CMC to share positive experiences may reduce opportunities for positive face-to-face social exchanges (Caplan, 2003) or may be used more frequently when an individual has persistently unsatisfying face-to-face interactions. Taking these findings into account provides an alternative explanation for the associations between CMC preferences and greater depression and difficulties with emotion regulation. That is, some individuals may experience greater social isolation in conjunction with CMC use, which may follow from, or exacerbate symptoms of, depression. In sum, Study 1 identified subscales in CMC communication preferences, which may be uniquely associated with individual differences in responses to emotion and to social-emotional functioning.

Study 2

Method

Participants—Twenty-two adults (11 females, 11 males), aged 18-47 years ($M = 22.95$, $SD = 6.65$), participated in Study 2. Participants were recruited through the psychology participant research pool at Hunter College, the City University of New York, as well as via campus advertisements. Self-reported race/ethnicity was: 1 (4.5%) African-American, 4 (18.2%) Hispanic, 6 (27.3 %) Caucasian, 10 (45.5 %) Asian, and 1 (4.5 %) reported other.

Materials and Procedure—Participation in this study lasted approximately 3 hours. Following informed consent procedures, participants completed the questionnaires described below. Participants then completed passive viewing (PV) and cognitive reappraisal (CR) tasks during which electroencephalography (EEG) data were recorded continuously. Participants sat approximately 65 cm away from a 17” IBM computer monitor on which stimuli were displayed in color using E-Prime version 2.0 (Psychological Software Tools; Pittsburgh, PA). At three points over the course of the lab visit, participants were asked to browse their Facebook page for five minutes and then categorize how they allocated that time (the Facebook Browsing Task). Participants were compensated with either course credit or $20 cash.

Big Five Inventory—The Neuroticism Scale from the 44-item version of the Big Five Inventory (John & Srivastava, 1999) was used to measure emotional instability, moodiness, irritability, anxiety, and sadness. This study specifically examined neuroticism as a covariate to account for individual differences in personality-based general negativity.

State-Trait Anxiety Inventory—The 20-item State-Trait Anxiety Inventory (Spielberger, 1983) assessed current anxiety by asking participants to evaluate their agreement with statements that describe common feelings on a four-point Likert scale, from one (not identifying with the statement at all) to four (identifying with the statement very much). State anxiety was examined as a covariate to account for individual differences in situation-based anxiety.

Social Support Scale—Participants completed the 12-item Social Support Scale (Sarason, Sarason, Shearin, & Pierce, 1987) to gather data about the quality and quantity of social support in their lives. Social support was operationalized as the average number of individuals available to provide support to the participants during periods of stress or pressure, or to offer consolation when needed, etc. Participants also reported the degree to which they were satisfied with the support received from these people on a scale from 0 (very dissatisfied) to 6 (very satisfied).

Emotion Regulation Questionnaire—Participants completed the 10-item Emotion Regulation Questionnaire (Gross & John, 2003) by indicating on a seven-point Likert scale the degree to which they agreed or disagreed with statements concerning their emotional experiences and emotional expressions. The questionnaire is designed to elicit information about techniques used to regulate emotions.

Facebook Browsing Task—The Facebook Browsing Task was used to assess patterns of CMC behavior and whether they related to CMC preferences measured via the SMCQ. On three occasions over the course of the three-hour lab visit participants were asked to browse their Facebook page for five minutes. They were instructed to interact with Facebook as they normally would, albeit with the caveat that they could not leave the website. After each five-minute period, participants recorded how much time they spent on different Facebook-related activities by completing a checklist based on research conducted by Wise et al. (2010). Each activity fit into one of four categories: *communications with friends* (e.g., writing on a friend's Facebook wall, engaging in chat), *social browsing* (e.g., passively looking at profiles), *impression management* (e.g., writing and posting status updates), and *other* (e.g., using apps and listening to music). If participants did not have a Facebook account ($n = 2$), the task was not conducted. Averages for time spent browsing in each of the four categories were calculated across the three browsing sessions.

Passive Viewing (PV) Task—Participants passively viewed 75 unpleasant, 75 pleasant, and 100 neutral images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Stimuli were presented for 2000 ms with a 1000 ms interstimulus interval and were randomly presented. Unpleasant ($f = 75$) and pleasant ($f = 75$) stimuli were further divided into subcategories. Unpleasant categories included: threat ($f = 35$), mutilation ($f = 22$), mortality ($f = 18$). Pleasant categories included: affiliative ($f = 42$), erotic ($f = 27$), and other ($f = 6$).

Cognitive Reappraisal (CR) Task—The CR task was similar to those used in several previous ERP studies (e.g. Krompinger, Moser, & Simons, 2008; Moser et al., 2010). Participants viewed the same 250 IAPS images from the PV task during the CR task. They were instructed to either maintain, increase, or decrease their emotional reaction to each image. At the beginning of the task, a research assistant explained real life examples of each type of emotion modulation (e.g. for decrease - "For example, think of how a doctor enters an emergency room. The doctor knows that he/she will be entering a negative environment and prepares him/herself to deal with that by decreasing the negative emotions he/she might feel when he/she enters the room."). Participants then completed a practice block of 12 trials (six increase, six decrease) to familiarize them with the emotion modulation prompts. Images were presented in two blocks of 25 and four blocks of 50 images, with block order and image selection randomized between participants but subject to the following rules: The

50-image blocks paired either 25 pleasant or 25 unpleasant images with 25 neutral images and within each block instructions were given to (1) either only increase or only decrease emotional reactions to the pleasant or unpleasant images, and (2) maintain emotional reactions to the neutral images. In the two blocks of 25 images, which contained either only pleasant or only unpleasant images, instructions were given to maintain emotional reactions to the images. Short breaks followed every second block. This protocol allowed for the collection of EEG data related to emotional regulation in seven different categories of cognitive reappraisal: INCREASE (pleasant and unpleasant images), DECREASE (pleasant and unpleasant images), and MAINTAIN (neutral, pleasant, and unpleasant images).

At the beginning of each trial, either the word increase, decrease or maintain appeared on the screen (2000 ms) to instruct the participants how to modulate their emotions. Each instruction was followed by an image (2000 ms) and then two questions that required participant response via keyboard entry. The first question asked the participant to rate the emotional valence of the image as either neutral ($M_{accuracy} = 0.72$, $SD_{accuracy} = 0.15$), pleasant ($M_{accuracy} = 0.54$, $SD_{accuracy} = 0.25$), or unpleasant ($M_{accuracy} = 0.79$, $SD_{accuracy} = 0.19$), and the second asked the participant to rate the intensity of the image on a Likert-like scale between 1 and 4, with 1 being “mild” and 4 being “very intense”. As expected, a repeated measures ANOVA revealed a significant main effect of condition on arousal ratings, $F(1, 21) = 113.08$, $p < .001$. Neutral stimuli ($M = 1.46$, $SD = 0.42$) were rated as significantly less arousing than both pleasant [$M = 1.98$, $SD = 0.62$; $t(21) = -5.239$, $p < .001$] and unpleasant [$M = 2.80$, $SD = 0.71$; $t(21) = -10.634$, $p < .001$]. Furthermore, pleasant images were rated as less arousing than unpleasant images, $t(21) = -7.718$, $p < .001$. In addition, a repeated measures ANOVA showed a significant main effect of emotion subtype (threat, mutilation, mortality, affiliative, erotic) on arousal ratings, $F(4, 84) = 44.87$, $p < .001$. Pairwise comparisons revealed that arousal ratings for each emotion subtype were significantly different (p's $< .01$), with the following pattern of arousal magnitude from least to most arousing: affiliative ($M = 1.86$, $SE = .13$), erotic ($M = 2.19$, $SE = .16$), threat ($M = 2.57$, $SE = .16$), mortality ($M = 2.84$, $SE = .15$), mutilation ($M = 3.12$, $SE = .15$). Following arousal and valance ratings, participants waited 2500 ms (an interstimulus “relaxation period”) for the next image to appear.

EEG Recording and Data Reduction: A BioSemi system (BioSemi; Amsterdam, NL), was used to record EEG activity continuously via 64 Ag/AgCl scalp electrodes placed in an elasticized nylon cap according to the international 10/20 placement system. Eye movements were monitored by electro-oculogram (EOG) signals from electrodes placed 1 cm above and below the left eye (to measure vertical eye movements) and 1 cm on the outer edge of each eye (to measure horizontal eye movements). The EEG signal was pre-amplified at each electrode to improve the signal-to-noise ratio. During data acquisition, EEG was recorded at a sampling rate of 512 Hz. The voltage from each of the 64 electrodes from which data was collected was referenced online with respect to the common mode sense active electrode, a procedure that produces a monopolar (nondifferential) channel. Brain Vision Analyzer (Version 2.2, Brain Products GmbH; Munich, DE) was used to prepare the data. Offline, all data were re-referenced to the average of the right and left mastoid electrodes and filtered with a high-pass frequency of .1 Hz and a low-pass frequency of 30 Hz. Stimulus-locked data were segmented into epochs from 200 ms before stimulus presentation to 2000 ms after stimulus onset, with a 200 ms baseline correction. These criteria are consistent with previous LPP studies using a minimum of 200 ms baseline correction (e.g. DeCicco et al., 2012; Kujawa, Hajcak, Torpey, Kim, & Klein, 2012; Kujawa, Klein, & Hajcak, 2012).

Artifacts in the EEG data were identified by ocular correction (Gratton, Coles, & Donchin, 1983) and removed from analysis in accordance with the following criteria: data with voltage steps greater than 50 μV, changes within a given segment greater than 300 μV, and activity lower than .5 μV per 100 ms. Trials were also visually inspected and any further artifacts and were removed on a trial-by-trial-basis.

The N1 was quantified as the mean amplitude from 90-120 ms over Fz during the PV task[3] (Figure 1), separately for pleasant and unpleasant emotion conditions, and subsequently for individual emotion subcategories (affiliative, erotic, threat, mutilation, mortality[4]). Difference scores were calculated to quantify early attention capture and reactivity to emotional versus neutral stimuli. For all N1 conditions, amplitudes to neutral images were subtracted from amplitudes to emotional images to yield difference scores. Larger (more negative) differences indicate greater attention capture and reactivity to the emotional versus neutral images.

The LPP was quantified as the mean amplitude from 200-800 ms over P3/P5/PO3/PO7 and P4/P6/PO4/P08 during the CR task[5] (Figure 2). Difference scores were calculated to quantify the degree to which CR resulted in increased or decreased LPPs, suggesting modulation of the LPP via reappraisal, and thus regulation. These difference scores were calculated by subtracting baseline LPP amplitude (the average LPP amplitude found during the neutral – maintain trials in that condition block) from the average LPP amplitude found in each of the six CR conditions examined in this study: INCREASE (pleasant and unpleasant images), DECREASE (pleasant and unpleasant images), and MAINTAIN (pleasant and unpleasant images). Larger difference scores indicated regulation in the predicted direction.

The LPP was also quantified as the mean amplitude from 200-800 ms over P3/P5/PO3/PO7 and P4/P6/PO4/P08 during the PV task. Difference scores were calculated (unpleasant or pleasant – neutral) to quantify the degree to which the magnitude of the LPP to emotional stimuli differed from that of neutral stimuli. For PV conditions (affiliative, erotic, threat, mutilation, mortality), amplitudes to the neutral condition were subtracted from amplitudes to emotional conditions. Larger amplitude difference scores indicate larger LPPs to emotional stimuli and suggest facilitated processing relative to neutral stimuli.

Results

Descriptive Statistics—Descriptive statistics for the SMCQ subscales **and the Facebook Browsing Task** are presented in Table 1 **and Table 2, respectively**. Pearson correlations

[3]The average trial count for PV (N1 and LPP) was 76.38 (*SD* = 13.65), with a lower limit of 50.00 trials.
[4]The ‘other’ pleasant category was not included in subsequent analysis of emotion subcategories due to the low trial count of that condition (*f* = 6).
[5]The average trial count for the LPP during the CR task was 23.38 (*SD* = 1.05), with a lower limit of 21.38 trials.

were conducted to test the prediction that greater CMC versus face-to-face communication preferences would be associated with reduced quality and satisfaction with participants' social support networks.

In Study 1, CMC versus face-to-face preferences were correlated to self-reported depression symptoms (BDI; Beck et al., 1996) and emotion regulation difficulties (DERS; Gratz & Roemer, 2004). No significant correlations were found between any of the SMCQ subscales and **depressive symptoms** (p's > .05) in the Study 2 sample.

As predicted, individuals who preferred to use CMC rather than face-to-face communication overall reported lower numbers of people available to them for social support. Similarly, a CMC preference for expressing distress was also associated with fewer people available for social support. Furthermore, those who preferred to use CMC for positive communication reported decreased satisfaction with their social support. In summary, a CMC preference was associated with reduced quality and satisfaction with social support networks **(Table 3).**

Pearson bivariate correlations were conducted to identify covariates to account for the potential contribution of personality-based general negativity and situation-based anxiety to CMC versus face-to-face communication preferences, as well as ERPs during the PV and CR tasks. No significant correlations emerged between CMC preferences and state anxiety or neuroticism (p's > .10). However, three significant correlations emerged with ERPs during the PV task: Greater state anxiety was associated with reduced N1s to erotic versus neutral stimuli ($r = .443$, $p < .05$), as well as all pleasant stimuli overall versus neutral stimuli ($r = .440$, $p < .05$), whereas greater neuroticism was associated with decreased LPPs to affiliative versus neutral stimuli ($r = -.456$, $p < .05$). Taken together, this pattern suggests that individuals' state anxiety and neuroticism are associated with decreased early and later reactivity, respectively, to pleasant stimuli. Based on these associations, neuroticism and state anxiety were used as covariates in subsequent analyses examining the association between CMC and ERPs.

Facebook Browsing Task and the SMCQ—Pearson bivariate correlations were conducted to examine relationships between patterns of use during the Facebook Browsing Task and CMC versus face-to-face communication preferences. A greater overall CMC preference was associated with a greater percentage of time spent on impression management ($r = -.498$, $p < .05$). Examining subtypes of preferences showed that it was specifically a greater CMC preference for expressing distress that was significantly associated with a greater percentage of time spent on impression management ($r = -.513$, $p < .05$).

CMC Preferences and ERP Responses—A series of regressions were conducted to test the predictions that greater CMC versus face-to-face communication preferences will be associated with greater magnitude ERPs (N1 and the LPP) during the PV task, and blunted ability to regulate emotional responses (reflected via LPP amplitudes) during the CR task. Self-reported neuroticism and state anxiety scores were entered as a covariates (neuroticism: 1st step, state anxiety: 2nd step) for all regressions. SMCQ scores (positive social communication, expressing distress, and casual communication) were entered in the 3rd step and each ERP condition difference score[6] was then entered separately as the dependent variable, for a total of 20 regressions. For the PV task, regressions were first conducted with pleasant and unpleasant aggregate scores as the dependent variables, and then regressions were conducted with emotion subcategories (affiliative, erotic, threat, mutilation, mortality) as dependent variables to evaluate the underlying, more-specific pattern of results.

Passive Viewing Task

LPP: CMC preferences did not predict LPP amplitudes to overall pleasant or unpleasant images (*p's* > .05). However, when emotion subtypes were examined separately, a CMC versus face-to-face preference for casual communication predicted reduced LPP amplitudes to affiliative images [β = **1.107**, $t(21)$ = **2.74**, p = **.01,** f^2 **= .42**].

N1: A CMC preference, averaged across all domains of communication, predicted greater amplitude N1 to pleasant images overall [β = 0.9**25**, $t(21)$ = 3.**03**, p **= .007,** f^2 **= .51**; Figure 3]. Individual CMC subscales were also related to N1 amplitudes to pleasant stimuli. A greater CMC versus face-to-face preference for expressing distress [β = 0**.587**, $t(21)$ = **2.12**, p **= .048,** f^2 **= .25**] and positive social communication [β = 0.8**08**, $t(21)$ = 3.**446**, p **= .003,** f^2 **= .66**] both predicted greater N1 amplitudes to pleasant stimuli. CMC preferences were not related to N1 amplitudes to unpleasant stimuli overall.

CMC subscales were also associated with N1 amplitudes to individual emotion stimulus types. An overall CMC preference predicted greater amplitude N1 to affiliative [β = 0.9**51**, $t(21)$ = 2.**34**, p **= .03,** f^2 **= .31**] and mutilation [β = 1.4**4**, $t(21)$ = **2.71**, p **= .01,** f^2 **= .41**] images. A CMC preference for expressing distress predicted greater amplitude N1 to mutilation [β = 1.1**8**, $t(21)$ = 2.7**1**, p **= .01,** f^2 **= .41**]. A CMC preference for casual communication [β = 0.808, $t(21)$ = 2.11, p = .049, f^2 = .25] significantly predicted greater amplitude N1 to affiliative images. Finally, a CMC preference for positive social communication significantly predicted greater amplitude N1 to erotic images [β = 1.**00**, $t(21)$ = 2.**12**, p **= .048,** f^2 **= .25**].

In summary, a CMC preference, versus a face-to-face communication preference, was associated with greater capture of attention by and reactivity to both pleasant and unpleasant stimuli. However, a CMC preference for casual communication and positive social communication predicted greater attention capture by distinct positively-valenced images (affiliative and erotic, respectively), while a CMC preference for expressing distress was uniquely associated with greater attention capture by mutilation images. This suggests that sub-types of CMC preference may be linked to unique aspects of affective attention capture and reactivity.

[6]N1 during PV task: all pleasant-neutral, all unpleasant-neutral, affiliative - neutral, erotic - neutral, threat - neutral, mutilation - neutral, mortality - neutral; LPP during PV task: all pleasant- neutral, all unpleasant-neutral, affiliative - neutral, erotic - neutral, threat - neutral, mutilation - neutral, mortality - neutral; LPP during CR task: pleasant decrease – neutral maintain, pleasant increase – neutral maintain, pleasant maintain – neutral maintain, unpleasant decrease – neutral maintain, unpleasant increase – neutral maintain, unpleasant maintain – neutral maintain

Cognitive Reappraisal Task

LPP: A CMC preference for casual communication predicted reduced LPP amplitudes when participants were asked to increase their emotional response to unpleasant stimuli [β = 1.**38**, $t(21)$ = **2.60**, p **= .02,** f^2 **= .37**]. No other associations with the LPP during the CR task reached significance.

Discussion

Results of the current study were consistent with the idea that a preference for CMC versus face-to-face interactions may be more pronounced in those who show increased attention capture by emotional images. Indeed, CMC may be perceived as less emotionally evocative or taxing method of communication, particularly among individuals who have a smaller social support network or perceive a low level of social support. Due to the correlational nature of these data, causal inferences about direct links between CMC and social-emotional functioning cannot be drawn. Findings are, however, a crucial first step in a future program of research that capitalizes on the sensitivity of neurocognitive measures to elucidate the emotional significance of CMC in the day-to-day lives of users.

First, communication preferences measured via the SMCQ were associated with actual patterns of social media use, measured via the Facebook Browsing Task. A greater preference for CMC was associated with a greater percentage of time spent on impression management, which includes writing and posting status updates which can serve as platform for emotional expression. This provides preliminary evidence that the SMCQ captures preferences that meaningfully relate to actual social media behavior. The Facebook Browsing Task does, however, have some limitations. Since participants were directed to browse Facebook at specific times, as opposed to at their leisure, their pattern of use may not precisely reflect how they would use Facebook to communicate in real life. In addition, participants were asked to estimate the percentages of time they spent on various activities. While this estimation was likely not overly demanding given the brief time span of the browsing task, the precision of the measurement could be improved by tracking use in real time. Despite these limitations, findings provide initial external validity for the SMCQ in that it can capture individual differences directly relevant to patterns of social media use.

A preference for CMC versus face-to-face interactions was associated with low social support, indicating that on average, individuals who either have a low amount of social support or are dissatisfied with that social support prefer to communicate emotions via CMC. This is consistent with the findings of Morahan-Martin and Schumacher (2003) indicating that lonely people used CMC more often to communicate negative emotions and elicit support from others, and were also more likely to report satisfaction with online interactions, compared to non-lonely individuals. Future research should examine how patterns of actual CMC use may facilitate social interactions for individuals with unsatisfactory face-to-face social networks.

Preferences for CMC versus face-to-face interactions were also associated with greater emotional attention capture and reactivity to both pleasant and unpleasant stimuli, as measured via greater N1 amplitudes during the PV task. However, each subscale appeared to have unique associations with greater attention capture by distinct types of emotional images: A CMC preference for casual communication with affiliative images, a CMC preference for positive social communication with erotic, and a CMC preference for expressing distress with mutilation images. These patterns highlight the importance of characterizing the nature of social communication goals when examining CMC in relation to neurocognitive and affective individual differences. For example, in future studies of actual CMC behavior rather than preferences, it will be crucial to carefully delineate the goals and motivations behind CMC use.

In contrast to findings for early attention capture measured via the N1, a CMC preference was related to a *decrease* in later elaborative processing (LPP) in the passive viewing task. This finding suggests that CMC preferences may be associated with an emotional profile in which very early and relatively automatic attentional biases towards arousing emotional material are exaggerated, but later, more elaborated processing of positive emotional stimuli is blunted. These findings underscore the importance of using temporally-sensitive measures like ERPs to examine individual differences in social-emotional processing and CMC preferences, and highlight a pattern of early attention capture by emotion, and reduced in-depth processing of positive emotional information. Consistent with this neurocognitive profile, the current study provides preliminary evidence that individuals with a preference for CMC interactions may also show reduced affective flexibility as demonstrated by the LPP. That is, they showed reduced ability to *increase* their emotional responding to unpleasant pictures during the CR task.

These ERP findings, when interpreted together, suggest that there may be a type of individual for whom social media may be used as a tool to regulate emotions. That is, social media use may be an adaptive response for individuals with low perceived social support, a tendency to be emotionally reactive, and reduced flexibility when trying to control their emotional responses. The current study does not suggest, however, that these patterns of CMC preferences are associated with maladaptive emotional adjustment outcomes, which may be due to the limited power afforded by the relatively small sample size. Future research should examine how CMC use can be used to support emotion regulation and whether certain emotional and/or neurocognitive profiles characterize individuals who prefer CMC versus face-to-face interactions to meet some social-emotional goals.

General Discussion

The current studies constitute crucial first steps toward developing an understanding of the relationships between how individuals choose to use CMC and their associated patterns of neural processing and regulation of emotions. Study 1 showed that the SMCQ yields statistically and theoretically distinct subscales that can be used to identify individual differences in core aspects of social media use. These subscales (positive social communication, expressing distress, and casual communication) may be employed to measure patterns of CMC use that distinguish individuals with varying degrees of social-emotional adjustment. Study 2 showed that preferences to use CMC for various types of emotional communication were related to satisfaction with social support and with specific patterns of emotional attention capture and regulation as revealed by ERPs.

In particular, Study 2 demonstrated that ERPs can serve as an important tool for examining individual differences in the time course of processing emotional content. By targeting both an early (N1) and late (LPP) component, we were able to distinguish between rapid attentional emotional processing and slower, more elaborative processing and regulation of emotions. In particular, previous research suggests that greater N1 amplitudes to emotional versus neutral stimuli indicate a greater degree of attentional capture by these emotionally arousing images (e.g. Cuthbert et al., 2000; Keil et al., 2001). In the current study, for example, individuals with a CMC preference showed greater N1 amplitudes to pleasant (affiliative and erotic) stimuli. Overall, N1 amplitudes were greater in response to positive emotional images of humans compared to non-human scenes (Groen et al., 2013), suggesting greater reactivity to social stimuli among those preferring CMC. Furthermore, Ruz, Madrid, and Tudela (2012) showed that N1 amplitudes were increased when participants saw an untrustworthy face in a social game, indicating enhanced attentional allocation to social-emotionally relevant information.

In the Study 2, individuals who preferred CMC versus face-to-face communication also showed greater N1 amplitudes in the mutilation condition, but not to unpleasant stimuli overall. One possible explanation for this lack of generalization to all unpleasant stimuli is that mutilation images are more socially oriented, and thus potentially more directly related to specific CMC preferences (in the present findings, that for expressing distress). For example, unlike the threat images which consist of unpleasant imagery focused on the self (e.g. gun pointed at viewer), the mutilation stimuli consisted of graphic images depicting injured people. Moreover, the mutilation pictures were rated as more arousing on average than the threat and mortality images, and thus might have triggered more intense affective reactions. Because greater N1 amplitudes to negative stimuli are associated with increased behavioral inhibition (Harmon-Jones, Gable, & Peterson, 2010), another possible interpretation of the current findings is that behaviorally-inhibited individuals show greater attention capture by negative stimuli and also have a preference to communicate distress via CMC because social media interactions are less intimidating than face-to-face interactions, particularly when emotions are involved. More research is needed to determine the relationships among individual differences in behavioral inhibition, early attention capture by emotional stimuli, and CMC use.

The use of temporally-sensitive ERPs in the current study also allowed for the targeted examination of later, elaborative emotional processes and regulatory flexibility via measurement of the LPP. A CMC preference was associated with decreased LPP amplitudes to affiliative stimuli, suggesting decreased sustained processing of this positive emotional image. Alternatively, the affiliative stimuli may have been interpreted as less motivationally salient among those who prefer CMC versus face-to-face communication. In addition, a CMC preference was associated with decreased ability to flexibly modulate emotional responses to unpleasant stimuli. This regulatory capacity has been linked to positive adjustment, while an inability to flexibly modulate emotions is related to negative adjustment outcomes (e.g. Gross & John, 2003; Moore, Zoellner, & Mollenholt, 2008). This finding may indicate that individuals with relatively poor regulatory capacity may use CMC as a tool to enhance attempts at emotion regulation. However, the only type of modulation impaired among those preferring CMC was increasing emotional responses to unpleasant stimuli, a condition that may not mirror any real life contexts where regulatory flexibility is essential for positive adjustment. Furthermore, the SMCQ subscale associated with this blunted regulation was casual communication, which reflects less emotionally salient topics like offering advice and communicating boredom. However, even taking these caveats into account, the current findings provide preliminary evidence for an association between CMC preferences and emotion regulation processes.

Despite these promising findings, several limitations must be addressed. First, the sample sizes of the current studies were relatively small, prohibiting the distinct categorization of participants into those who preferred CMC and those who preferred face-to-face communication. However, examination of participants on a spectrum from pure CMC preference to pure face-to-face preference may be more reflective of how individuals conceptualize their own preferences. An additional limitation is that the current studies included only normative samples. Several studies have indicated a link between high anxiety and CMC (e.g. Pierce, 2009; Rauch, Strobel, Bella, Odachowski, & Bloom, 2014). For example, Caplan (2006) found that social anxiety predicted a CMC preference, which in turn predicted negative outcomes including missing social activities and job/school obligations due to online engagement. Also, Rauch et al. (2014) found that when individuals with social anxiety were exposed to a stranger's Facebook profile, they showed greater skin conductance when they subsequently interacted with that person face-to-face, suggesting that Facebook use may lead to increase anxiety in later interactions in person.

Based on this pattern of findings, future research should target recruitment of individuals with high anxiety to determine if the pattern of results is consistent with those of the normative sample in the current study. Furthermore, the interpretation of the results is limited to associations among variables and no causal inferences can be drawn. For instance, it is unclear whether a CMC preference is the result of a preexisting pattern of attention capture by emotional stimuli, or if individuals with heightened emotional attention capture turn to CMC to communicate emotions. To begin to answer this question, future research could examine the longitudinal impact of CMC to communicate and regulate emotions, particularly across childhood and adolescence, periods of both drastic emotional changes and increasingly frequent social media engagement.

Taken together, the current findings provide a crucial initial step towards understanding the associations between CMC use, neurocognitive processes, and social-emotional adjustment. The current findings suggest a profile of a type of emotionally-reactive individual who may use social media adaptively to compensate for low perceived social support and reduced regulatory capacity.

Appendix

Appendix

Principle Components of the SMCQ

SMCQ Factor	Factor Loading	α 7	α 8
Component 1: Positive Social Communication Subscale		**.78**	**.77**

SMCQ Factor	Factor Loading	α[7]	α[8]
Chat with friends	**.53**		
Keep in touch with people	**.82**		
See what friends have been doing	**.86**		
Get to know people	**.82**		
Talk to someone I don't know well	**.66**		
Component 2: Expressing Distress Subscale		**.87**	**.72**
Communicate worry	**.84**		
Communicate anger	**.62**		
Have a disagreement	**.58**		
Feeling scared	**.78**		
Seek emotional support	**.75**		
Seek advice	**.51**		
Share upset	**.65**		
Communicate sadness	**.60**		
Communicate disgust	**.58**		
Component 3: Casual Communication Subscale		**.70**	**.70**
Learn more about someone	**.63**		
Offer advice	**.77**		
Communicate interest	**.57**		
Communicate surprise	**.77**		
Communicate boredom	**.61**		

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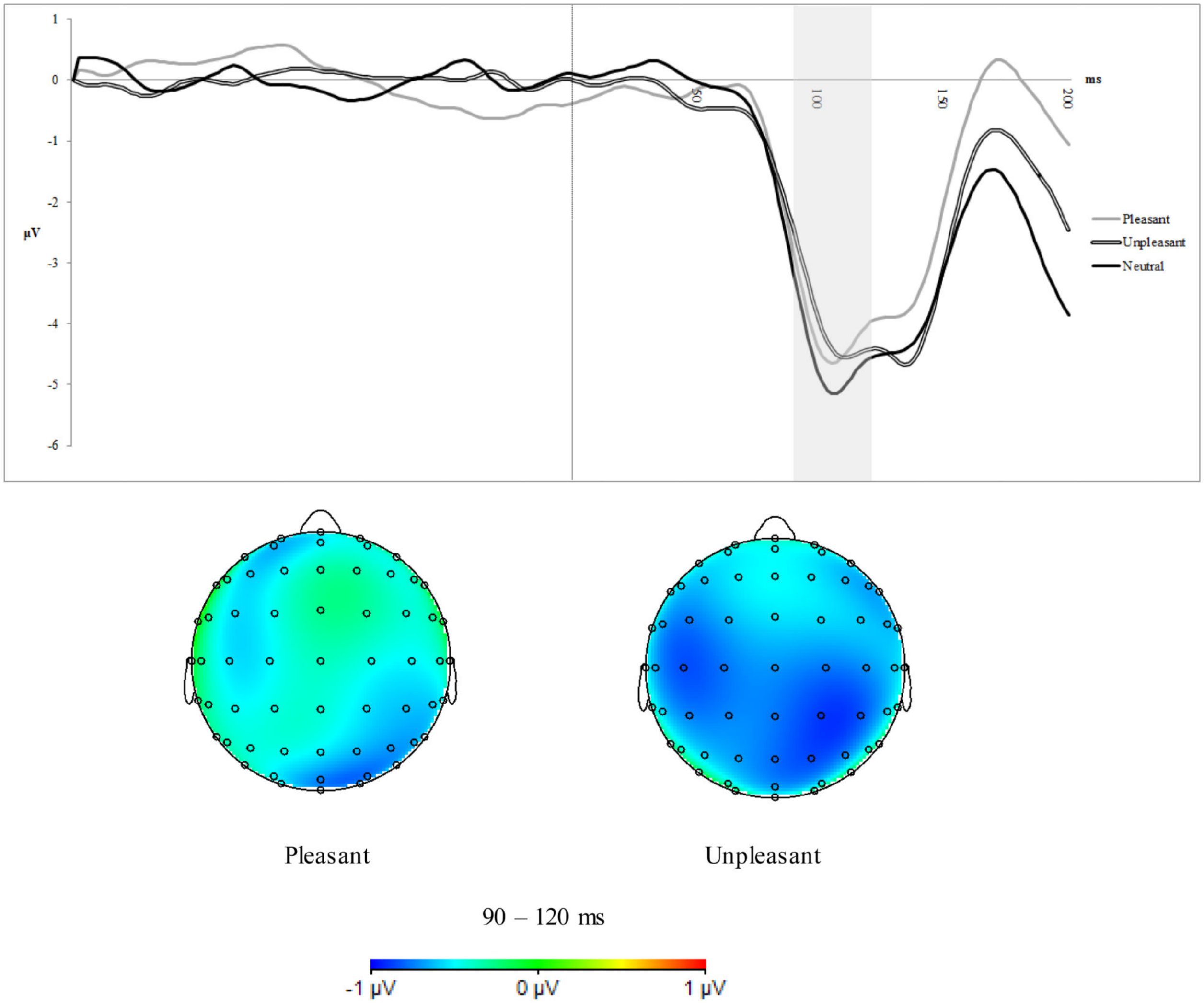

Figure 1.

Waveforms by condition depicting the N1 at Fz between 90 ms and120 ms. The headshots illustrates the grand average difference scores for the N1 across the pleasant (minus neutral) and unpleasant (minus neutral) conditions.

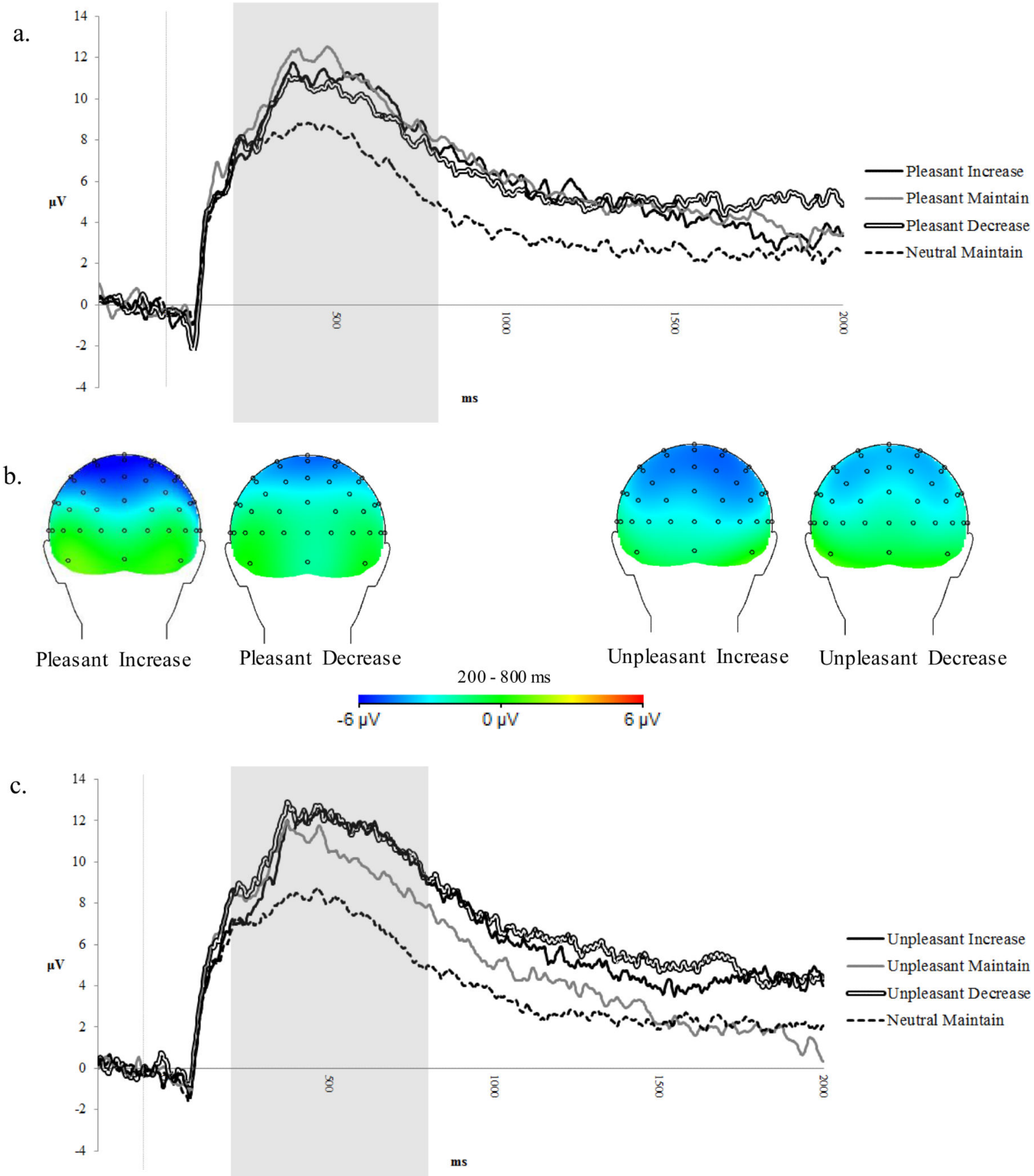

Figure 2.

(a) LPP waveforms for pleasant-increase, pleasant-maintain, pleasant-decrease, and neutral-maintain conditions. The neutral-maintain waveform is averaged across pleasant blocks (increase and decrease). (b) The headshots illustrate the grand average difference scores for the pleasant-increase (minus neutral maintain), pleasant-decrease (minus neutral maintain), unpleasant-increase (minus neutral maintain) and unpleasant-decrease (minus neutral maintain) conditions. (c) LPP waveforms for unpleasant-increase, unpleasant-maintain, unpleasant-decrease, and neutral-maintain conditions. The neutral-maintain waveform is averaged across unpleasant blocks (increase and decrease).

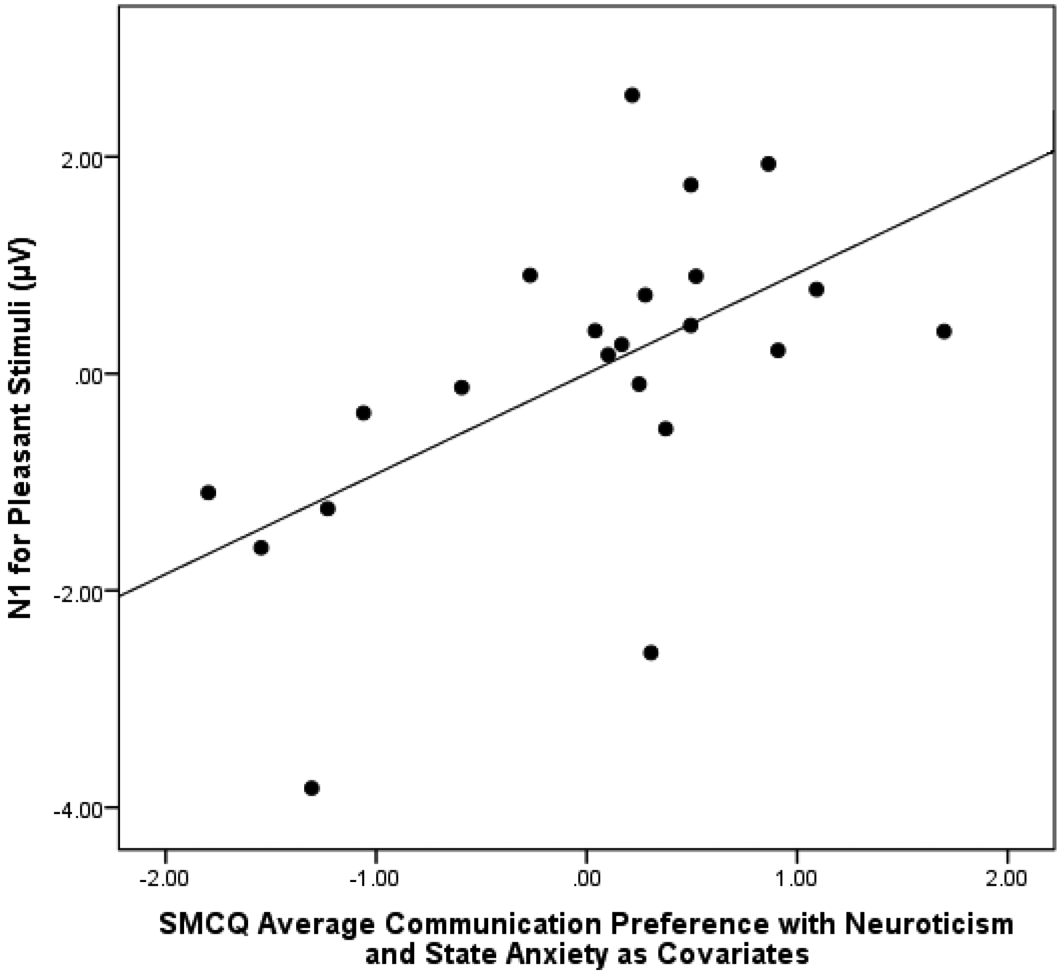

Figure 3.
A greater overall preference for CMC was associated with greater (more negative) amplitude N1 to pleasant versus neutral stimuli.
Note. The x-axis represents the sample distribution of SMCQ scores taking neuroticism and anxiety into account, ranging from − 2.00 SD (CMC preference) to +2.00 SD (face-to-face preference).

Table 1

Descriptive Statistics for the SMCQ Scale

SMCQ Scale	Minimum Score	Maximum Score	*M (SD)*
Positive Social Communication Scale	1.00	5.40	3.63 (1.13)
Expressing Distress Scale	2.14	6.44	4.79 (1.12)
Casual Communication Scale	1.75	6.00	4.21 (1.00)
Average Communication Preference Scale	2.31	5.84	4.26 (0.92)

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Table 2

Descriptive Statistics for the Facebook Browsing Task

Facebook Activity Type	Minimum Percentage	Maximum Percentage	*M (SD)*
Communications with Friends	0.00	85.00	30.92 (25.46)
Social Browsing	0.00	100.00	33.81 (25.82)
Impression Management	0.00	40.00	5.69 (11.41)
Other	3.33	98.33	44.03 (29.04)

Table 3

Correlations between the SMCQ and Social Support Scale

	Average number of people available for social support	Average satisfaction with level of social support
SMCQ Positive Social Communication	.395	.443*
SMCQ Expressing Distress	.455*	.076
SMCQ Casual Communication	.412	.299
SMCQ Average Communication Preference	.507*	.276

Note. N = 22 for all correlations

SMCQ scales – lower scores indicate greater CMC preference

* $p < .05$, 2-tailed