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Research report

Comparison of text messaging and paper-and-pencil for ecological momentary assessment of food craving and intake

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A B S T R A C T

Electronic devices such as mobile phones are quickly becoming a popular way to gather participant reports of everyday thoughts, feelings, and behaviors, including food cravings and intake. Electronic devices offer a number of advantages over alternative methods such as paper-and-pencil (PNP) assessment including automated prompts, on-the-fly data transmission, and participant familiarity with and ownership of the devices. However, only a handful of studies have systematically compared compliance between electronic and PNP methods of ecological momentary assessment (EMA), and none have examined eating specifically. Existing comparisons generally find greater compliance for electronic devices than PNP, but there is variability in the results across studies that may be accounted for by differences across research domains. Here, we compared the two EMA methods in an unexamined domain – eating – in terms of response rate and response latency, and their sensitivity to individual difference variables such as body mass index (BMI). Forty-four participants were randomly assigned to report on their food craving, food intake, and hunger four times each day for 2 weeks using either a PNP diary (N = 19) or text messaging (TXT; N = 25). Response rates were higher for TXT than PNP (96% vs. 70%) and latencies were faster (29 min vs. 79 min), and response rate and latency were less influenced by BMI in the TXT condition than in the PNP condition. These results support the feasibility of using text messaging for EMA in the eating domain, and more broadly highlight the ways that research domain-specific considerations (e.g., the importance of response latency in measuring short-lived food craving) interact with assessment modality during EMA.

Introduction

Ecological momentary assessment (EMA) is a relatively new but growing approach for measuring everyday experiences (e.g., behaviors, thoughts, mood/emotion) in vivo and with high temporal specificity (Shiffman, Stone, & Hufford, 2008; Trull & Ebner-Priemer, 2013). EMA entails repeated measurements within and across days (e.g., four times each day for 14 days) that, depending on the research goals, can occur randomly, on a fixed schedule, or be triggered by specific events. In any case, one of the main advantages of EMA is its ability to minimize retrospective bias by eliciting reports from participants more closely in time to the event of interest than would otherwise be possible with post hoc measurements based on recollection. A second advantage is that reports are obtained in vivo and are thus more ecologically valid than those gathered in a laboratory. For these reasons, EMA has been used to provide unique information about psychological, behavioral, and clinical outcomes ranging from mood (Ebner-Priemer & Trull, 2009) and relationship quality (Laurenceau & Bolger, 2005) to cigarette smoking (Shiffman, 1993) and food intake (Thomas, Doshi, Crosby, & Lowe, 2009).

The present study focuses on compliance rates of EMA in the domain of food intake and craving. Researchers in the food domain have embraced EMA because of its ability to measure food intake and food-related affect (e.g., craving) as it occurs naturally during everyday life. Food craving is also short lived (Werthmann et al., 2011), making response latency an important consideration in this area. Preliminary evidence suggests that EMA via electronic devices, and particularly text messaging, is feasible for assessing appetite and food intake (Schembre & Yuen, 2011), and even among children (Shapiro et al., 2008). Building on this, a number of pilot studies have begun to test the efficacy of weight loss and other dietary interventions based on text messaging, generally with encouraging results (Cole-Lewis & Kershaw, 2010; Gerber, Stolley, Thompson, Sharp, & Fitzgibbon, 2009; Napolitano, Hayes, Bennett, Ives, & Foster, 2012; Patrick et al., 2009). Electronic EMA-based interventions (or “ecological momentary interventions”; Heron & Smyth, 2010) are particularly relevant in the realm of dietary intervention because of the effect of mere self-monitoring on intake (Burke et al., 2009). Nonetheless, the majority of studies to date using EMA to monitor

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or intervene upon intake use the paper-and-pencil (PNP) method (see Burke, Wang, & Sevick, 2011 for review), and to our knowledge electronic and PNP EMA have not been directly compared in this area. Thus, the overarching purpose of the present research is to directly compare response rates and latencies between these two types of EMA in the eating domain. We believe that quantifying the differences in response rate and latency between PNP and electronic methods is an important first step in the comparison between the two.

Early EMA studies used paper-and-pencil (PNP) diaries as the medium, sometimes aided by electronic reminders (e.g., Larson & Csikszentmihalyi, 1983). As portable device technology developed, researchers deployed electronic devices that minimized subject burden and increased data fidelity including Palm Pilots (Feldman Barrett & Barrett, 2001) and, more recently, short-message service text messaging (TXT; Berkman, Dickenson, Falk, & Lieberman, 2011). The key advantages of electronic devices over PNP for EMA are: (a) time stamping to thwart possible forward- or backfilling of entries, (b) built-in prompting or signaling (e.g., auditory or tactile) at preset times, (c) input gating to ensure that responses conform to criteria (e.g., a 1–5 Likert scale), (d) the potential for instantaneous wireless data transfer to reduce data loss in the event that the diary device is lost, stolen, or broken, and (e) generally greater convenience and accessibility for participants. In the case of text messaging, most participants are already familiar with the interface and own the device, which increases compliance because they are more likely to have it with them at all times and less likely to lose or forget the device. These considerable advantages have led researchers increasingly to use electronic devices not only for EMA-based observational studies but also for EMA-based interventions (Heron & Smyth, 2010).

Despite the enthusiasm for electronic EMA, only a few studies have directly compared it with older, more extensively validated PNP methods. An initial study comparing the two methods (Stone, Shiffman, Schwartz, Broderick, & Hufford, 2002) found that participants in the PNP group reported completing 90% of the assessments within 15 min of the targeted time, but a covert light-sensitive computer chip revealed that only 11% of the responses were actually in compliance. By comparison, the actual completion rate for electronic EMA in that study was 94%. Subsequent studies that took steps to equate the two methods in other ways (e.g., by providing audible alerts and giving feedback on compliance) found more comparable response rates between PNP and electronic methods as well as comparable patterns in the data in terms of central tendency and covariance (Green, Rafaeli, Bolger, Shrout, & Reis, 2006). One study in the paper by Green et al. (2006) elicited a 94% completion rate from participants in the PNP condition (compared with 92% in the electronic version), and the authors concluded that compliance likely varies as a function of study design and participant motivation more than it does by data collection format. Nonetheless, the reliability of self-reports of PNP completion has remained a controversial topic (Broderick & Stone, 2006), and scientists have emphasized the need for more research on this issue with particular attention to variability in completion rates across research domains (Tennen, Affleck, Coyne, Larsen, & DeLongis, 2006).

The goal of the present study is to directly compare PNP and TXT formats for EMA of food intake and craving. Specifically, we compared response rates (i.e., compliance), response latency, and user experience across 14 consecutive days of EMA with four assessments per day between two groups of individuals who had been randomly assigned to either a PNP or electronic format. The TXT EMA was delivered using text messaging, and the PNP EMA was delivered using a pocket-sized diary. To facilitate a "fair" comparison (Tennen et al., 2006), we used electronic time-stamp verification for the PNP method and took steps to equate the experimental procedures for the two conditions aside from differences inherent in the assessment format. As an exploratory aim, we also gathered several individual difference measures to test if compliance was systematically related to trait-level variables and, if so, whether that differed between the EMA formats (e.g., Courvoisier, Eid, & Lischetzke, 2012). We reasoned that several broad personality traits (impulsivity, self-control, and the big five traits agreeableness, conscientiousness, extraversion, neuroticism, and openness) and a food intake-specific measure (body mass index; BMI) might relate to compliance in either or both groups.

Method

Participants

A total of 44 participants (30 female, age M = 21.25, SD = 2.32, range = 18–30) completed the study after being recruited through flyers placed around the University of Oregon campus. Participants were randomly assigned to either the PNP (N = 19) or the TXT (N = 25) EMA formats (see Table 1 for demographics by group). Participants were paid $10 for the baseline session, $5 for the endpoint session, $5 per week of EMA, and an additional $5 per week that they responded to 90% or more of the prompts. Thus, participants would receive at least $25 if they participated in the entire experiment, and as much as $35 if they completed more than 90% of the prompts in both weeks. All gave informed consents in accordance with the University of Oregon Institutional Review Board.

Procedure overview

The study consisted of 2 weeks of daily EMA of food intake and craving bookended by one baseline and one endpoint laboratory session. All participants were emailed nightly during the EMA phase with a reminder (that was identical between conditions) to complete all assessments the following day in a timely manner.

Baseline session

At the baseline session, participants completed questionnaires assessing individual differences in self-control, impulsivity, and personality: the 13-item Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004; M = 4.05, SD = .91, α = .83; 1 = "completely disagree," 4 = "neutral," 7 = "completely agree"), the Barratt Impulsivity Scale (BIS-10; Patton, Stanford, & Barratt, 1995; M = 2.48, SD = .23, α = .62; 1 = "rarely/never," 2 = "occasionally," 3 = "often," 4 = "almost always/always"), and the Big Five Inventory (BFI; John,

Table 1
Demographics for each group and for the total sample.

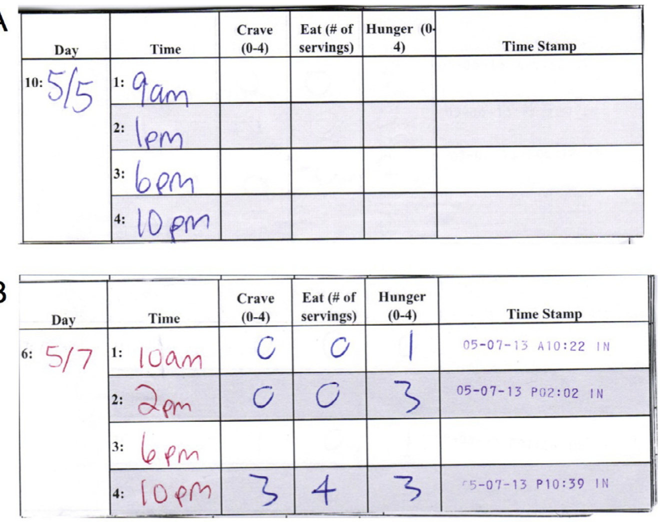
	Paper and pencil	Text messaging	Total
Number of subjects	19	25	44
# Female/Male	13 F/6 M	17 F/8 M	30 F/14 M
% Female/% Male	68.4 F/31.6 M	68 F/32 M	68.2 F/31.8 M
Age (SD)	20.26 (1.098)	22.00 (2.722)	21.25 (2.324)
Response rate (SD)	69.91% (29.5)	95.87% (3.78)	84.66% (23.27)
Response latency (SD)	78.93 m (40.56)	29.02 m (16.09)	50.58 m (38.19)

Donahue, & Kentle, 1991; agreeableness: M = 3.73, SD = .49, α = .65; conscientiousness: M = 3.57, SD = .67, α = .82; extraversion: M = 3.32, SD = .91, α = .9; neuroticism: M = 3.04, SD = .71, α = .8; openness: M = 3.88, SD = .54, α = .74; 1 = "strongly disagree," 3 = "neither agree nor disagree," 5 = "strongly agree"). At this session, participants also reported their current height and weight, from which we calculated BMI (weight in kg/height in m^2; M = 22.1, SD = 3.33, range = 17.5–33.9). None of these measures differed significantly by EMA group (P-values > .1). The incentive structure was also explained at this session, noting the bonus payment ($5 per week) for a 90% or greater completion rate.

EMA

Upon completion of the questionnaires at the baseline session, participants were randomized into a group and then trained by the experimenter on the EMA procedure they were to adhere to for the following 14-day period. All participants identified their typical meal times (breakfast, lunch, and dinner) and bedtime so that the four prompts per day could be scheduled to occur approximately at the end of each meal and just before bed. We note that we used a mealtime-based EMA schedule, as opposed to a more common random schedule, because we were specifically interested in food-related responses near mealtimes. In addition, all participants identified a "target" energy-dense food to monitor for the 14-day period. Target foods were selected to be high-calorie, readily available, and often consumed when the participant was not hungry (e.g., a snack or dessert food). At each of the four time points, participants in both groups rated: (a) their current craving for the target food on a five-point Likert scale (0 = Not at all, 4 = Very strong), (b) the number of servings of their target food they had consumed since the last prompt (using a numerical count of servings), and (c) their current level of general hunger on a give-point Likert scale (0 = Not at all, 4 = Very hungry). Participants in both groups were instructed to respond as closely as possible to the target time, and only to reply to the single most recent prompt. For example, if a participant was scheduled to respond at 9am and 12pm, to make a rating at 12:05pm he/she was instructed to reply only to the 12pm prompt regardless of whether or not a response was made at the 9am prompt. Participants were prompted four times each day for 14 days, totaling 56 prompts across the EMA period.

PNP EMA participants were given a bag containing a data entry packet and a tamper-proof digital time stamper. The data entry packet contained one page for each day (14 pages total), each prefilled with the dates and times of each prompt (Fig. 1a), spaces for the three ratings (with brief explanations of the rating scales), and a space to time-stamp when the entry occurred. Participants in the PNP EMA condition were instructed to complete each assessment as closely as possible to the target time indicated in the packet and to imprint a time stamp when they completed the assessment. We decided not to use an additional prompting method


A

Day	Time	Crave (0-4)	Eat (# of servings)	Hunger (0-4)	Time Stamp
10: 5/5	1: 9am				
	2: 1pm				
	3: 6pm				
	4: 10 pm				

B

Day	Time	Crave (0-4)	Eat (# of servings)	Hunger (0-4)	Time Stamp
6: 5/7	1: 10am	0	0	1	05-07-13 A10:22 IN
	2: 2pm	0	0	3	05-07-13 P02:02 IN
	3: 6pm				
	4: 10pm	3	4	3	05-07-13 P10:39 IN

Fig. 1. A representative page from the 14-page paper-and-pencil packet. The cover page included full wordings for each of the three rating items as described in the text. (A) Each page was prefilled by the experimenter at the baseline session to include the four assessment points based on each participant's meal times and bedtime. (B) A representative page from a completed packet with one missing response. Note that response latencies can be calculated by comparing the time stamp with the target time for each prompt.

(e.g., pre-programmed wristwatches) for participants in the PNP condition for two reasons. First, we wanted to estimate compliance for PNP EMA as it is most commonly deployed in the research literature (i.e., without prompts). Second, the one published study on this topic of which we are aware found that pairing PNP EMA with electronic reminder signals does not necessarily increase compliance rates (Broderick, Schwartz, Shiffman, Hufford, & Stone, 2003). Thus, beyond the nightly emails and the written schedule in the data entry packet, PNP participants were not reminded about when to complete their assessments. Figure 1b shows a representative page reflecting 1 day's worth of responses for one participant; the target response times were entered into the packet by the experimenter during the baseline session, and the responses and time stamps were completed by the participant during EMA. Response latency was computed by comparing the target time to the time indicated by the stamp.

TXT EMA participants were given a card containing explanations of the rating scales (identical to those in the PNP data entry packet), as well as a description of the response format to be used for the TXT EMA ratings (Fig. 2). TXT EMA prompts were delivered four times per day via text messaging at each of the target times using an automated text messaging service (mProve, http://

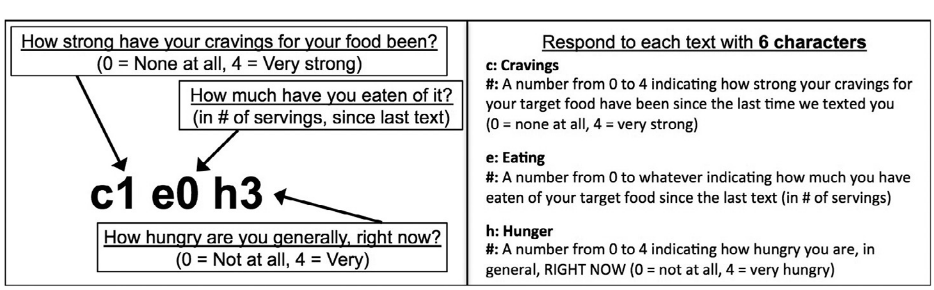


Fig. 2. The "cheat sheet" laminated card that was provided to electronic EMA participants. (Left) The front of the card contained a description of the six-digit alphanumeric code that participants used to respond to the three items at each prompt. (Right) The back of the card contained the full rating item for craving, food intake ("eating"), and hunger.

www.mprove.com). TXT EMA participants were instructed to respond to the text messages when they received the prompt, but no later than the subsequent prompt. The prompt read, “Please rate your craving (c: 0–4), eating (e: servings), and hunger (h: 0–4) in a single text (e.g., c1e0h3),” and participants replied with their response in a single text message using the alphanumeric code provided on the card. The code paired a letter for each question (“C” for craving, “E” for eating, and “H” for hunger) with a number for the response using the scale indicated on the card (i.e., five-point Likert for craving and hunger, and number of servings for eating). For example, a response for very strong craving, no eating, and very high hunger would be “C4 E0 H4.” This alphanumeric code method has been used successfully in the past to measure craving for and smoking of tobacco cigarettes (Berkman et al., 2011). Participants in the TXT EMA condition we offered a “loaner” phone with sufficient prepaid time to cover all text prompts and responses, but all participants elected to carry their own phones. Sixty-four percent of the TXT participants possessed smartphones, though there were no significant differences in response rates ($F(1,23) = .97$, ns) and latencies ($F(1,24) = 2.06$, ns) between smartphones and standard phones. We reminded participants to carry their phones at all times.

Endpoint session

At the endpoint session, all participants completed a user experience questionnaire assessing their satisfaction with the EMA response format they used, problems they had with their response format, and whether they would have preferred another response method. Finally, an experimenter tallied completion rates and provided compensation at the end of the session.

Data analysis

Valid responses were defined by the following criteria: within the acceptable numeric range (0–4 for craving and hunger ratings, integer for servings consumed), logged before the subsequent target time, and logged on the same day as the target time (i.e., next-day responses to bedtime prompts were excluded). Invalid responses were catalogued according to error type: non-numeric or out of the acceptable number range (“unacceptable”), before the target time (“early”), and after the subsequent target time (“late”). Response latency was calculated as a continuous variable in minutes from the target time and visualized using a histogram of the number of responses in 30-min bins (e.g., from the target time to 30 min after; from 31 to 60 min after, etc.).

All variables were checked for normality using the Shapiro–Wilk test; variables that were significantly non-normal were transformed to improve normality. Specifically, BMI was subjected to a −2 power transformation (i.e., BMI^{-2}), which improved the fit of the distribution to normality from $P < .001$ to $P > .6$. The rest of the individual difference variables all passed the Shapiro–Wilk test ($P > .05$), both within each method group and across all participants. Independent samples t-tests were used to compare the variables of interest between the groups, and Pearson’s correlations were used to assess the linear relationship between individual difference variables and response rate/latency. For all tests, alpha was set at $P < .05$.

Results

Response rate and errors

Participants in the TXT EMA group responded at significantly more of the target times than participants in the PNP EMA group (PNP: M = 69.91% valid response rate, SD = 29.49%; TXT: M = 95.87%, SD = 3.78%; $t(42) = 19.09$, $P < .001$). Compared with the TXT EMA group, participants in the PNP group produced more responses that were before the target time (PNP: M = 3.05, SD = 5.76; TXT: M = .0,

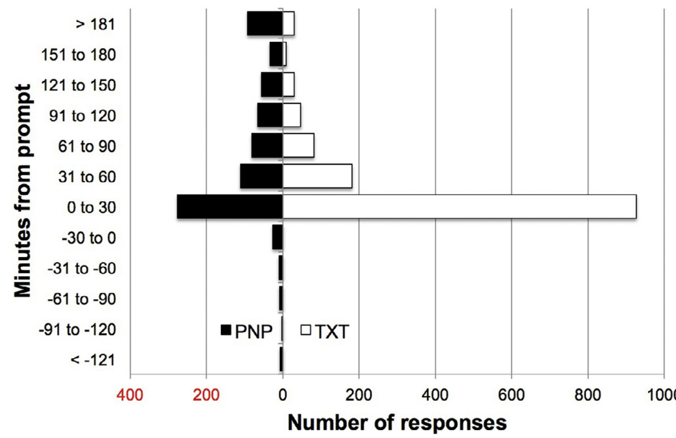


Fig. 3. Histogram of the number of responses that the PNP (left) and TXT EMA (right) group made within each 30-min time bin relative to the target time.

SD = .0; $t(42) = 7.08$, $P = .011$). There was no significant difference in the number of unacceptable (PNP: M = 2.0, SD = 5.95; TXT: M = .48, SD = 1.53; $t(42) = 1.51$, $P = .23$) or late responses between the groups (PNP: M = 1.37, SD = 5.03; TXT: M = .0, SD = .0; $t(42) = 1.89$, $P = .18$), with few unacceptable or late responses in either group.

Response latency

Participants in the TXT EMA group responded significantly closer to the target time (in terms of target-to-response latency) than participants in the PNP group (PNP: M = 78.93 min, SD = 40.56; TXT: M = 29.02 min, SD = 16.09; $t(42) = 31.54$, $P < .001$). As shown in Fig. 3, participants in the TXT EMA group responded to significantly more prompts within 30 min of the target time (i.e., from 15 min before to 15 min after) than the PNP group (PNP: M = 15.0 or 26.8%, SD = 12.86; TXT: M = 33.5 or 59.9%, SD = 7.79; $t(42) = 45.73$, $P < .001$). This same pattern holds for several other “fences” that might be used to define timely responses vis-à-vis the target time, including 60 min (PNP: 39.2%, TXT: 71.1%), 90 min (PNP: 47.3%, TXT: 77.7%), and 120 min (PNP: 54.9%, TXT: 85.0%, all $ts(42) > 10.00$, $ps < .001$) within the target time.

Correlations with individual difference measures

As an exploratory aim, we examined the correlations between response rate and latency with BMI and several other individual differences measures, and compared these correlations between the two groups (Table 2). Response rate correlated negatively with BMI in both groups, but to a significantly greater degree in the PNP ($r = -.49$, $P = .03$) versus the TXT group ($r = -.24$, $P = .26$; group × response rate interaction on BMI: $F(1,39) = 3.96$, $P = .054$). Response latency correlated positively with BMI in both groups (PNP: $r = .49$, $P = .03$; TXT: $r = .40$, $P < .051$). The positive relationship between BMI and latency did not differ between the groups, suggesting that individuals with higher BMIs tended to have longer response latencies, and this effect was not altered by EMA type. In both groups, response rates and response latency were negatively related to each other (PNP: $r = -.20$, $P = .41$; TXT: $r = -.44$, $P = .029$), and these correlations were not significantly different from one another (interaction: $P = .29$) even though the correlation reached significance in the TXT group and not the PNP group. Summarizing the results regarding the differential relations of BMI to compliance, participants with higher BMI had longer response latencies in general but lower response rates only in the PNP group.

Table 2
Correlations between response rate/latency and individual differences by group.

	Response latency	Self-control	Impulsivity	E	A	C	N	O	BMI
Method: PNP									
Response rate	–.2	–.05	–.17	–.25	–.22	.15	.21	–.17	**–.49***
Response latency		–.28	–.17	.10	**.52***	.07	–.36	.17	.49*
Self-control			.02	.04	–.13	.17	–.14	–.08	–.27
Impulsivity				.24	–.18	–.05	.37	.05	.01
Extraversion					–.13	–.13	–.56*	–.10	.16
Agreeableness						.54*	–.33	.63*	.44
Conscientiousness							–.03	.30	–.15
Neuroticism								–.19	–.12
Openness									.09
Method: TXT									
Response rate	–.44*	.01	.02	.16	–.02	.19	–.15	–.33	**–.24**
Response latency		.07	.21	–.44*	**.06**	–.13	.14	–.08	.40
Self-control			–.04	.36	.14	.64*	–.56*	–.01	.17
Impulsivity				.14	.18	.18	.10	.33	.51*
Extraversion					.29	.33	–.35	.33	–.23
Agreeableness						.13	–.21	.24	–.12
Conscientiousness							–.52*	.15	.32
Neuroticism								–.11	–.08
Openness									–.05

Note: Values listed are Pearson's r values. A = agreeableness; BMI = body mass index; C = conscientiousness; E = extraversion; Imp = impulsivity; N = neuroticism; O = openness.
* $P < .05$. Correlations in **bold** are significantly different between the two EMA groups.

Next, we examined the differential correlations between the two groups with the other individual difference measures. PNP response rate did not relate significantly to any of the other individual difference measures (all *ps* > .30), and PNP response latency was related positively only to agreeableness ($r = .52$, $P = .023$). This relationship was significantly stronger in the PNP group compared with the TXT group (TXT: $r = .06$, $P > .7$; group × response latency interaction on agreeableness: $F(1,40) = 6.65$, $P < .05$). In the TXT group, only extraversion was significantly related (negatively) to mean response latency ($r = –.44$, $P = .026$), but not to a greater magnitude than in the PNP group (interaction $P = .23$). In sum, among the individual difference measures, only agreeableness related differentially with response latency such that individuals high in agreeableness had greater latencies in the PNP than in the TXT EMA method.

User experience

Finally, we examined group differences in user experience in terms of participant ratings of satisfaction, self-efficacy to use the method, and preference for another method. Participants in the PNP group reported being significantly less satisfied than those in the TXT EMA group (PNP: M = 3.37, SD = 1.12; TXT: M = 4.0, SD = .92; $t(42) = 4.26$, $P = .045$). Self-efficacy to provide accurate ratings was high in both groups (PNP: M = 3.79 of 5, SD = 1.08; TXT: M = 4.04, SD = .74) and did not differ between groups ($P = .37$). When asked whether they would prefer another assessment method, 14 of the 19 PNP participants (73.7%) reported that they would have preferred either a text- or online-based method, whereas only one of the 25 TXT EMA participants (4%) reported that she preferred another method (a once-per-day email schedule). The preference for an alternative method was significantly different between the two groups (chi-squared = 23.33, $P < .01$).

Discussion

The present study compared PNP and TXT EMA for assessing food intake, food craving, and hunger. Our main goal was to compare response rates, response latencies, feasibility, and acceptability of these two types of EMA in the eating domain, where EMA is increasingly popular but has received little methodological attention. We found that participants using the TXT EMA format versus the PNP format had a greater mean response rate (96% versus 70%) and a smaller latency to the target response time (29 min versus 79 min), and were also more satisfied with their EMA experience and less likely to prefer a different format. This is the first study to directly compare these two EMA formats in the eating domain, and among the first to use time-stamps to examine response latencies in the PNP format and compare them with latencies in the TXT format. Our results consistently favor TXT EMA over PNP in terms of response rate, response latency, and user experience, and highlight the utility of text messaging for electronic EMA, particularly in the eating domain where shorter response latencies are highly valuable.

The present results provide further support for the feasibility of conducting EMA using text messaging. Text messaging is low cost (typically less than $.01 per message) and, though brief (i.e., up to 160 characters), can be ideal for certain types of EMA assessment such as brief questionnaires using Likert or count ratings. Text messaging is also highly familiar to most participants, who increasingly own their own text-enabled phones, and is more accessible in low-income and rural areas than alternative electronic EMA formats such as smartphone applications or PDAs. A recent report from the Pew Research Center found that 91% of people in the United States have a mobile device, nearly all of which are text messaging-enabled, whereas only 45% owned smartphones (Smith, 2013). Formerly used mostly by young people, the demographics of texting have shifted to include 87% of individuals aged 55–64, and 76% of those 65 and above (Smith, 2013). Participants who do not already own such devices can be provided with pre-paid phones (typically <$20), and text messages can be purchased in bulk for less than $.01 each. At that rate, sampling each participant four times each day for 60 days costs less than $5. Together with the data presented here, these statistics indicate that text messaging is an ideal way to gather repeated, brief assessments for low cost with high compliance and fast responses from nearly any population.

An interesting set of exploratory findings that may be specific to the food-related nature of the prompts was the relationship between BMI and response rate/latency. Notably, BMI was related to response rate (negatively) and response latency (positively) in the PNP condition. Individuals higher in BMI tended to respond less often and more slowly. The directions of these relationships were the same in the TXT condition, but the magnitude of the effect for response rate was significantly smaller. One possible interpretation of these results is that people with higher BMI might have found reporting on their food intake and craving more aversive than those with lower BMI, and thus avoided or delayed responding when possible. If that were the case, then the difference between conditions might be attributable to text messaging being more accessible, as people are increasingly using mobile phones for multiple modes of communication. This increased accessibility and fluency with the TXT response method may explain the smaller relationships between BMI and response rate/latency specifically, and the increased response rates and reduced latencies in the TXT condition compared with PNP generally. Indeed, recent research has shown that many people find text messaging and phone checking to be very compelling (Augner & Hacker, 2012; Takao, Takahashi, & Kitamura, 2009; Walsh, White, & Young, 2008). The fact that all individuals in this study used their own phones further supports this interpretation.

Two other interesting exploratory results emerged in the relationship between response latency and individual differences measures. Specifically, agreeableness related positively to response latency in the PNP group (and related to a greater degree in the PNP group than in the TXT group), and extraversion related negatively to response latency in the TXT group (though not to a different degree than in the PNP group). It is notable that these relationships emerged in the response latency but not the response rate metric, suggesting that individual differences are more relevant to how long it takes to respond than whether or not a response is ultimately provided. Perhaps individuals high in agreeableness were more likely to delay responses in the PNP condition because responses using format cause a greater disruption to ongoing social activities than responses in the TXT format; in contrast, perhaps individuals high in extraversion responded more quickly in the TXT condition because they used their phones – all of which were text-enabled, and many of which were also smartphones – more often for communication and social media. Though we believe these to be reasonable interpretations, we emphasize that we offer them only as possibilities, and that more targeted research will be needed to conclusively address the relationship between personality traits and response latency/rate.

The importance of response latency is not limited to the food domain. Latency is relevant in any assessment domain with a time-sensitive measure such as mood/emotion (Keltner & Gross, 1999), drug craving (Sayette et al., 2000), and medication compliance (Claxton, Cramer, & Pierce, 2001). Despite its importance for a range of measures, latency has been evaluated less often than compliance in comparison studies of EMA, perhaps because of the challenges to accurately measuring the time of completion for PNP studies. Thus, one of the main strengths of the present study is the use of tamper-proof digital time stampers to assess the timing of responses in the PNP condition. That technique gave us a high degree of confidence that the stamps were made at the indicated time, though there is no guarantee that the responses were made at the same time as the stamp. For example, a participant could have time-stamped the response sheet within minutes of the target time, then backfilled the responses at a later time. However, we minimized this possibility by making it as easy as possible to complete the three rating items on the PNP survey: participants only needed to write three numbers; each assessment point had a designated place in the packet; and the packet, time stamper, and a pen were provided in a single baggie to participants so that if they had the stamper and the packet then they also had a pen with which to make the ratings. Thus, we find it unlikely that participants regularly remembered and took the time to imprint a timestamp, but then later backfilled responses.

The present study has some additional limitations. First, the sample size (N = 44) is relatively small, but the effect sizes of the main comparison of response rate/latency between groups was large (Cohen's d > 1.0 in both cases), so the study was adequately powered to detect and estimate these effects. Second, the age range and demographics of the sample is also relatively limited, which may limit the generalizability of the findings. Future work could investigate how response rate/latency varies between the two EMA methods in different populations (e.g., school aged adolescents, older adults, etc.) Third, a key difference between the two methods was the presence of an audible prompt in the TXT condition. We deliberately chose not to add a response prompt so that our PNP condition would be representative of PNP as it is most commonly deployed in the literature. We believe the use of a pre-scheduled booklet (in the absence of reminder signals) in the PNP condition is a strength of the study because it provides an explicit schedule to the participants in the PNP condition without directly prompting them at a particular time (e.g., with an auditory signal). Lastly, because we chose to schedule our prompts to occur after mealtimes and before bed, the conclusions of the present study are limited to ratings made on a fixed schedule. Further research is needed to compare the response rate/latency of the two methods when used with a random schedule or with ratings that are event-contingent.

We close by echoing the conclusion of others (e.g., Tennen et al., 2006) that the overall feasibility to TXT EMA might be highly dependent on the research domain and context. Here, we saw outstanding response rates and short response latencies for numeric ratings of food craving and intake – measures that are relatively easily quantified and fluctuate rather quickly, lending themselves to a fast and short (e.g., six character) response format. However, it is not hard to imagine a slightly different research question, for example, regarding the social context in which energy-dense eating occurs, that is less easily quantified using a Likert-style question and instead lends itself to a brief textual response. There, even though text messaging may be feasible (i.e., that a text response could fit under 160 characters such as, "I was with friends at a party"), participants might find a PNP diary to be more convenient depending on their level of facility with typing whole sentences into a mobile phone. Other applications might require less awkward response entry than the alphanumeric code used here, or skip logic where later queries depend on earlier responses. Smartphones might be preferable for those purposes. Better still, high-resolution cameras on mobile phones might be a new frontier for research questions involving food intake (Martin et al., 2012), superseding both PNP and other electronic formats as a fast and reliable way of gathering EMA data for that purpose. The degree of variability in response rates, and likely in response latencies, is likely attributable at least in part to the extent to which the particular research question is amenable to assessment using the chosen method. In turn, this implies the need for further studies such as this one that compare various forms of EMA in specific research domains.

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