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ORIGINAL ARTICLE

Validation of a Novel Delay Discounting of Text Messaging Questionnaire

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Abstract Using cellular phones for text messaging has become a ubiquitous mode of communication in today's American culture. Text messaging has become a primary source of relationship development and maintenance for many Americans, especially youth. Researchers have begun classifying excessive reliance on text messaging as an addictive behavior, which may lead to risky activities such as texting while driving. This study interprets texting dependence within a behavioral economics framework of addictive behavior and proposes a novel Delay Discounting of Texting Questionnaire (DDTQ). The DDTQ involves a hypothetical scenario wherein the respondent chooses between paying for an immediate text now and waiting to receive a free text message in the future. We validated the DDTQ using a relatively diverse crowdsourced sample from Amazon Mechanical Turk. The DDTQ demonstrated expected degrees of systematic discounting and yielded higher rates of delay discounting with reward values in a within-subjects evaluation of the magnitude effect. Finally, the DDTQ successfully discriminated different profiles of possible text-messaging dependence. Collectively, these findings suggest the DDTQ is a viable task for use in studying the behavioral economics of possible text-messaging dependence.

Keywords Text message · Technology · Cellular phone · Delay discounting · Behavioral economics · Amazon Mechanical Turk

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The recent Pew Research Center report, *Teens, Technology and Friendships*, reveals how deeply texting (including various forms of messaging enabled by apps and other services such as Apple iMessage) has become part of the social fabric for the typical American youth (Lenhart, Smith, Anderson, Duggan, & Perrin, 2015). When making new friends, 54 % said "a phone number for texting" was the first thing they shared with new friends. For comparison, the second most common was social media username at 18 %. A similar number, 55 %, indicate they spend time with friends via text daily, compared to only 25 % that report spending time face to face every day with friends. Texting is the number one way that they get in touch with their closest friend, with 49 % reporting doing so compared to social media, a distant second at 20 %, and calling by phone only reported by 13 % of teens as the most common way to contact their closest friend.

However, not just teens demonstrate reliance on cell phones. A Pew Research Center report, *Mobile Technology Fact Sheet* (Pew Internet Project, 2014), suggests that 90 % of American adults owned a cell phone, as of 2014. Of these cell phone owners, 34 % report using their cell phone as their primary means of accessing the Internet, and 81 % of adult users use their phone to send or receive text messages (which is the top cell phone activity for adults). Other recent Pew Research findings indicate that nearly 29 % of cell phone users report their smartphone is something "they couldn't live without" (Pew Research Center, 2015). It is unsurprising, then, that addictive behaviors specialists from around the globe have begun classifying cellular phone dependence in their respective countries of origin (e.g., Billieux, van der Linden, D'Acremont, Ceschi, & Zermatten, 2007).

Despite its dependence liability, using cellular phones for texting may be useful (or perhaps even prosocial) in contexts such as relationship development and maintenance (see Lehhart et al., 2015). In contexts such as driving, however,

texting can be deadly. Texting is more likely to divert attention and the eyes away from the roadway for longer durations than other distractions (National Highway Traffic Safety Administration, 2011). Younger drivers are more likely to be involved in fatal crashes due to driving while distracted (National Highway Traffic Safety Administration, 2013). Younger drivers recognize the risk of texting and driving, rating it as more risky than driving drunk (Atchley, Hadlock, & Lane, 2012). But because teens are dependent on phones for important social activities, and *over*valuing texting as an important lifeline for social connection (see Atchley & Warden, 2012), the compulsion to immediately text can override considerations of safety. Understanding this dependence on texting, as well as developing techniques to measure it, is a critical research problem.

The behavioral profile of dependence on immediate texting is comparable to other addictive behavior profiles assessed using behavioral economic principles (Bickel et al., 2012; Bickel, Jarmolowicz, Mueller, & Gatchalian, 2011; Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Jarmolowicz, Reed, & Bickel, 2015). At the backbone of such the behavioral economic view of addiction is the quantitative marker known as *delay discounting* (see Madden & Bickel, 2010). Put simply for the case of texting, individuals dependent on texting should prefer access to texting immediately, even if there is a potential cost associated with doing so.

To determine the extent to which individuals prefer the immediacy of texting, Atchley and Warden (2012) compared traditional monetary delay discounting to a novel texting delay discounting procedure where participants chose between receiving a small amount of money immediately by replying to a text message and receiving a larger amount of money for waiting a specified delay to reply to the text message. When delays were normalized across the two procedures, the researchers found the shape of the texting delay discounting curve closely resembled traditional monetary delay discounting, suggesting decision making related to texting may be largely affected by the delay. However, the data also suggest the monetary reward, when paired with texting, loses its value much more quickly and across a shorter time frame as compared to only the monetary reward.

Despite numerous conceptual and methodological contributions, Atchley and Warden's study leaves several remaining questions. First, their texting delay discounting procedure included alternatives where money was gained *in addition* to viewing the text, rather than the text itself. It is thereby unknown whether the value of texting by itself is affected by delay. In addition, the procedure may not approximate the "real world" because it is unlikely an individual would be paid to view and respond to a text message. It is unknown whether a more likely scenario featuring a cost associated with texting immediately would yield findings conceptually systematic with delay discounting. Finally, while the procedure resulted in promising results, it is unknown whether common manipulations, such as magnitude effects, known to modulate monetary discounting would also affect discounting of text messaging; documenting such modulation would help establish the validity of the procedure.

Given the aforementioned review, there is a need for a validated discounting procedure able to quantify how the value of text messaging is affected by delay. The overarching goal of the current study was to create and validate a discounting procedure related to text messaging. Validation of the discounting procedure would be achieved if the following aims are met: (1) responses on the discounting assessment are systematic, (2) the task is sensitive to previous manipulations shown to affect discounting rate (e.g., magnitude effect), and (3) the task is able to discriminate populations (i.e., frequent vs. infrequent text-messaging users).

The robust literature on delay discounting indicates that as delay increases, subjective value of the outcome decreases; researchers have thereby developed objective criteria by which responses on a discounting task may be considered systematic (Johnson & Bickel, 2008). Therefore, the task would be considered valid if the vast majority of participants' responses meet these objective criteria for systematic discounting. The discounting literature is replete with examples demonstrating the magnitude of the outcomes modulates rates of discounting (Dai, Grace, & Kemp, 2009; Estle, Green, Myerson, & Holt, 2006; Green, Myerson, Holt, Slevin, & Estle, 2004; Green, Myerson, & Ostaszewski, 1999; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013). We hypothesize that access to text messages associated with a larger price will result in shallower rates of discounting (i.e., greater self-control), consistent with the magnitude effect. Moreover, central to the discounting literature is that clinical populations (e.g., drug abusers, pathological gamblers) tend to display steeper (i.e., more impulsive) rates of discounting as compared to normative controls (see MacKillop et al., 2011, for a meta-analysis). We hypothesize that individuals who are more dependent on cellular phone use for text messaging will display steeper rates of discounting as compared to more typical individuals.

Method

Participants

Participants were recruited from Amazon Mechanical Turk and completed the survey as a human intelligence task (HIT). The survey was accessible only to those Amazon Mechanical Turk Workers in the United States for whom previous requesters had accepted 95 % or more of their previous HITs and had completed at least 100 approved HITs. Workers were paid $0.60 if they completed the HIT and submitted a

unique survey completion code within 35 min. On average, Workers' latency to HIT submission was 4.76 minutes (*SEM* = 10 s), approximating an hourly wage of $7.56. Workers who submitted a HIT are thereby considered participants in this study.

To ensure data validity, participants' data were excluded from analyses if (a) they did not complete the entire survey or (b) their responding on the delay discounting of texting task failed to meet a criterion adapted from Johnson and Bickel (2008; see details below). A total of 111 of 122 participants (91 %) provided complete and valid datasets for analysis. Of the 111 participants, 65 % were female ($n = 79$); ages ranged from 18 to 64 years ($M = 35.2$, $SEM = 1.1$); 77 % reported their ethnicity as White, 11 % were Black or African American, and ~12 % consisted of Asian, Native Hawaiian or Other Pacific Islander, and other.

Materials

All survey materials were administered via a HIT survey link, which directed Workers to a Qualtrics Survey Suite battery of tasks. The tasks included general demographic questions (e.g., gender, age, ethnicity), a short version of the Self-Perception of Text Message Dependency scale (Igarashi, Motoyoshi, Takai, & Yoshida, 2008), general questions relating to cellular phone use (Billieux et al., 2007), and two novel delay discounting of texting questionnaires.

Delay Discounting of Texting Questionnaire (DDTQ) The DDTQ consisted of a visual analog scale (VAS) and asked participants to indicate their likelihood of waiting a specific delay to access and read a text message. Both versions of the delay discounting of texting questionnaire contained the following vignette:

> "Suppose that your cellular phone data/texting provider has instituted a new plan that places a delay on your ability to check your text messages after you are notified that one has arrived. If you choose to immediately read and reply to the text message, your plan provider will charge you $__.
> Given this scenario, imagine that you just received notification of delivery of a text message from your most intimate partner/friend, but cannot immediately view it given the new texting plan. How likely are you to wait for the message to unlock and avoid the $__ charge if the delay to unlocking for free is:"

The VAS is a 100-mm horizontal line with descriptive anchors on each end: "Not likely to wait; check now and pay $__" and "Likely to wait the full delay to unlock for free." Both versions were identical except for the monetary amounts: $5.00 or $0.50. The VAS was displayed immediately below the vignette. Participants were asked to click on the slider and move it on the horizontal line to indicate their likelihood of waiting the full delay to unlock the text message for free. There were seven delays (1 min, 5 min, 30 min, 1 hr, 4 hr, 8 hr, and 24 hr), and each delay consisted of a VAS with all seven being presented on the same page (presented sequentially on the same screen in a series of individual rows immediately below the vignette).

Self-Perception of Text Message Dependency The short version of the Self-Perception of Text Message Dependency scale consisted of 15 items and served to measure the individuals' perception of their text-message usage. The original scale (Igarashi, Motoyoshi, Takai, & Yoshida, 2005) identified three factors via factor analysis: *perception of emotional reaction, excessive use,* and *relationship maintenance*. For the purpose of the current study, we used a short version developed by Igarashi et al. (2008) containing five representative items from each of the subscales. On the initial scale, each item was on a 5-point Likert scale anchored by *strongly agree* (1) to *strongly disagree* (5). We reverse scored all items such that higher scores indicates stronger agreement to remain consistent with interpretations of items on our questionnaire relating to cellular phone use.

Questionnaire Relating to Cellular Phone Use The questionnaire relating to cellular phone use was adapted from Billieux et al. (2007) and consisted of five items. Four of the five items asked about general cellular phone use ("*Do you own a cellular phone?*", "*On average, how long do you use your cellular phone per day?*", "*On average, how many calls do you make in one day?*", and "*On average, how many text messages do you write per day?*"), and one item related to the individual's level of dependence on their cellular phone ("*Evaluate your level of dependence on your cellular phone, keeping in mind that the larger the percentage, the higher the level of dependence*"). The item asking about cellular phone dependence was anchored by "0 %" and "100 %." Because all 111 participants reported owning a cellular phone, subsequent analyses were restricted to the four other items.

Procedures

Participants were presented with an information statement approved by the University of Kansas Human Subjects Committee (#20635). Upon consent, participants completed the two versions of the DDTQ, presented in a counterbalanced order across participants. Next, participants completed the Self-Perception of Texting Dependency Scale and the questionnaire relating to cellular phone use, also presented in a counterbalanced order. Finally, participants were presented the general demographics questionnaire.

Data Analysis

To determine whether the DDTQ yielded systematic responding, we applied criterion 1 of Johnson and Bickel's (2008) algorithm for systematic delay discounting to the data, which states that *increases* in the dependent variable across increases in delay violates the assumption of systematic discounting, with tolerance of up to a 20 % increase of the larger, later amount. Our use of *likelihood of waiting* as the dependent variable for our discounting task results in a larger, later amount of "100," such that 100 % likelihood of waiting is theoretically discounted by the delay until the text message is delivered for free. Participants were thereby excluded if any likelihood of waiting response on the DDTQ increased by more than 20 % across increasing delays on *either* magnitude assessments. As an example, we excluded data from a participant who reported the following values: 26, 48, 21, 61, 38, 54, and 78 % across the seven delays of 1 min, 5 min, 30 min, 1 hr, 4 hr, 8 hr, and 24 hr, respectively. Eleven of our 122 participants (9 %) violated criterion 1 on one or both of the $5.00 and $0.50 DDTQ tasks; these participants' complete datasets were excluded from all subsequent analyses.

We did not apply criterion 2 of Johnson and Bickel's (2008) algorithm because, as the authors state, "depending on the delays utilized and the nature of the study, it may be considered valid for an individual to discount by less than 10 % from the first to last time point, and criterion 2 may be eliminated" (p. 270). Since the current study is exploratory in nature and because the longest delay used was 24 hrs, it was quite possible that some individuals would demonstrate exclusive responding (i.e., 100 % likely or 0 % likely) across all delays. Indeed, in the $0.50 condition, nearly a quarter ($n = 23$) of the participants showed exclusive responding and in the $5.00 condition, 39 participants showed exclusive responding.

Given the novelty of the DDTQ, we relied on an atheoretical approach to analyzing delay discounting that simply calculates area under the discounting curve (AUC; Myerson, Green, & Warusawitharana, 2001), rather than using nonlinear regression according to theoretical models of delay discounting (Madden & Bickel, 2010; McKerchar et al., 2009; Myerson & Green, 1995; Reed, Kaplan, & Brewer, 2012). The Myerson et al. AUC calculation uses the trapezoidal method to calculate AUC, which is then converted to proportion of maximum possible AUC (and may thereby range from 0.00 to 1.00). Relatively small AUC indicates relative impulsivity in the intertemporal tradeoff (i.e., substantial discounting of value as a function of time); conversely, relatively large AUC indicates relative self-control (i.e., minimal discounting).

One benefit of using the AUC approach to analyze discounting data is that it typically results in a relatively normal distribution of parameters (i.e., absent of significant skewness or kurtosis). Given the exploratory nature of the task, we graphed the distribution of parameters, and as illustrated in Fig. 1, for both $0.50 and $5.00 conditions, the estimates were not normally distributed. Rather, the distributions were bimodal with the highest proportion of values being close to either 0 or 1.[1]

To address our second aim of validating the DDTQ, a paired t test (alpha = .05) was used to determine whether AUC differed within-subjects across the $5.00 and $0.50 versions. To address the third aim of demonstrating differentiation on the DDTQ, because of the bimodal distribution of AUC values we used a split-median approach to separate the 111 participants into low-AUC (more impulsivity on the DDTQ; $n = 56$) and high-AUC (more self-control on the DDTQ; $n = 55$) groups within the $5.00 and $0.50 versions, separately. This meant that the same participant could be classified as low AUC in the $0.50 group but as high AUC in the $5.00 group. Within each DDTQ version ($0.50 and $5.00), unpaired t tests (alpha = .05) were used to compare the low-AUC and high-AUC groups on three subscales of the Self-Perception of Text Message Dependency scale (Perception of Emotional Reaction, Excessive Use, and Relationship Maintenance) and questionnaire items relating to cellular phone use. Finally, due to violations of normality, we conducted a Spearman rank-order correlation to examine relations between the various text-messaging measures (see Table 1).

Results

Aim 1: Demonstrate Systematic Responding

Applying criterion 1 of Johnson and Bickel's (2008) algorithm for identifying systematic discounting, only 9 % (11) of the original sample ($N = 122$) yielded unsystematic responses.

[1] We ran the exponential (Yi, Landes, & Bickel, 2009), simple hyperbolic (Mazur, 1987), and hyperboloid (Green & Myerson, 2004) discounting models for individuals who did not display exclusive responding and compared fits using Akaike's information criteria (AIC). For both the $0.50 and $5.00 conditions, AIC results indicated preference in the following order: exponential > simple hyperbolic > hyperboloid. We note that this is an abnormal finding; however, the task involves both losses ($0.50 or $5.00 payment) and gains (ability to read text message immediately), which preclude direct theoretical comparisons to other discounting studies. The cross-commodity nature of money and text messaging further obfuscates conceptualization within standard accounts of delay discounting. Nevertheless, we are not the first to report findings suggesting that a simple exponential function outperforms theoretically derived models of delay discounting (e.g., Bickel, Yi, Landes, Hill, & Baxter, 2011). Future research should seek to disentangle these features to better account for theory; such a theoretical venture, however, was outside the scope of this study.

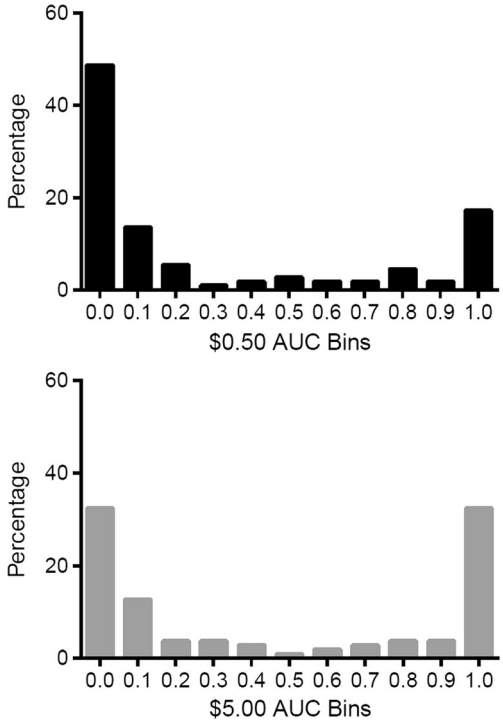

Fig. 1 Distribution plots (percentage of responses) of AUC values across 0.10 unit bins for $0.50 (top panel) and $5.00 (bottom panel) amounts. Note the extreme skews toward both ends for both amounts (i.e., not normally distributed)

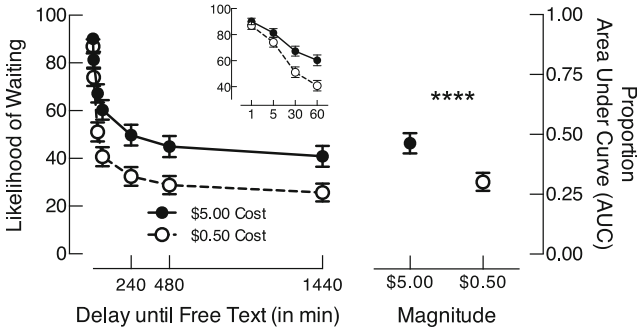

Fig. 2 Results from the DDTQ. Left panel plots (mean) likelihood of waiting as a function of delay until free receipt of text message (in min) for both $5.00 (closed circles) and $0.50 (open circles) immediate delivery costs. Inset provided to better illustrate likelihood of waiting at small delays. Right panel plots mean proportion AUC for both DDTQ magnitudes. Error bars indicate *SEM* in both panels. **** $p < .0001$

Aim 2: Demonstrate Magnitude Effect

The left panel of Fig. 2 illustrates mean likelihood of waiting for a free text message is discounted as a function of the delay until its receipt. The data presented in the left panel of Fig. 2 replicates the robust literature supporting a curvilinear discounting function (Madden & Bickel, 2010), further corroborating Atchley and Warden's (2012) finding that a discounting process may describe text-messaging patterns. The aggregate data in the left panel of Fig. 2 depict clear differentiation between the $5.00 and $0.50 discounting functions, suggesting a possible magnitude effect.

We compared AUC across the $5.00 and $0.50 magnitudes within subjects to determine whether the DDTQ was sensitive to the well-established magnitude effect. Average AUC was significantly higher in the $5.00 magnitude condition ($M = .46$, $SEM = .042$) relative to the $0.50 magnitude condition ($M = .30$, $SEM = .037$), $t(110) = 5.66$, $p < .0001$, indicating a magnitude effect in the expected direction. The right panel of Fig. 2 illustrates this difference in AUC magnitude.

Aim 3: Demonstrate Differentiation via the DDTQ

The third aim of the current study was to demonstrate the validity of the DDTQ; namely, its ability to differentiate chronic text-messaging users from less-frequent users. Toward this end, we compared participants' ratings on a commonly used and validated questionnaire to quantify text-

Table 1 Correlation matrix

Measure	1	2	3	4	5	6	7	8	9
1. $5.00 AUC	—								
2. $0.50 AUC	.75***	—							
3. Emotional reaction	-.22*	-.25**	—						
4. Perception of excessive use	-.29**	-.26**	.32***	—					
5. Relationship maintenance	-.19	-.16	.45***	.51***	—				
6. Minutes per day	-.23*	-.39***	.18	.35***	.18	—			
7. Calls per day	-.02	-.06	.01	.15	-.08	.27**	—		
8. Texts per day	-.30**	-.25**	.25**	.72***	.48***	.47***	.17	—	
9. Self-reported dependence	-.26**	-.30**	.14	.49***	.34***	.49***	.25**	.36***	—

Note. Spearman rank-order correlation ($n = 111$).

*$p <= .05$. **$p <= .01$. ***$p <= .001$.

messaging dependence: Self-Perception of Text Message Dependency (Igarashi et al., 2008). The three factors identified by Igarashi et al. (2005, 2008) may be considered subscales; the scale developers recommend that researchers refrain from collapsing these factors into one composite score, given the nature of the factor loadings.

The top panel of Fig. 3 depicts group differences on the Self-Perception of Text Message Dependency. In the $0.50 condition, participants with low AUC reported significantly stronger emotional reactions related to text messaging ($M = 15.29$, $SEM = 0.60$) compared to participants with high AUC ($M = 13.15$, $SEM = 0.62$), $t(109) = 2.48$, $p < .05$. Similar results were obtained with perception of excessive use, with the low-AUC group reporting significantly higher scores ($M = 14.68$, $SEM = 0.67$) than the high-AUC group ($M = 12.89$, $SEM = 0.56$), $t(109) = 2.02$, $p < .05$. We found no difference in AUC groups' relationship maintenance, however, $t(109) = 0.84$, $p = .40$. In the $5.00 condition, similar results were obtained. Low-AUC participants reported significantly stronger emotional reactions ($M = 15.34$, $SEM = 0.63$) compared to participants with high AUC ($M = 13.10$, $SEM = 0.59$), $t(109) = 2.61$, $p < .05$. Low-AUC participants also scored higher on their perception of excessive use ($M = 15.21$, $SEM = 0.64$) as compared to high-AUC participants ($M = 12.35$, $SEM = 0.57$), $t(109) = 3.33$, $p < .01$. Similarly, participants with low AUC scored significantly higher on measures of relationship maintenance ($M = 11.50$, $SEM = 0.54$) as compared to participants with high AUC ($M = 9.87$, $SEM = 0.53$), $t(109) = 2.13$, $p < .05$.

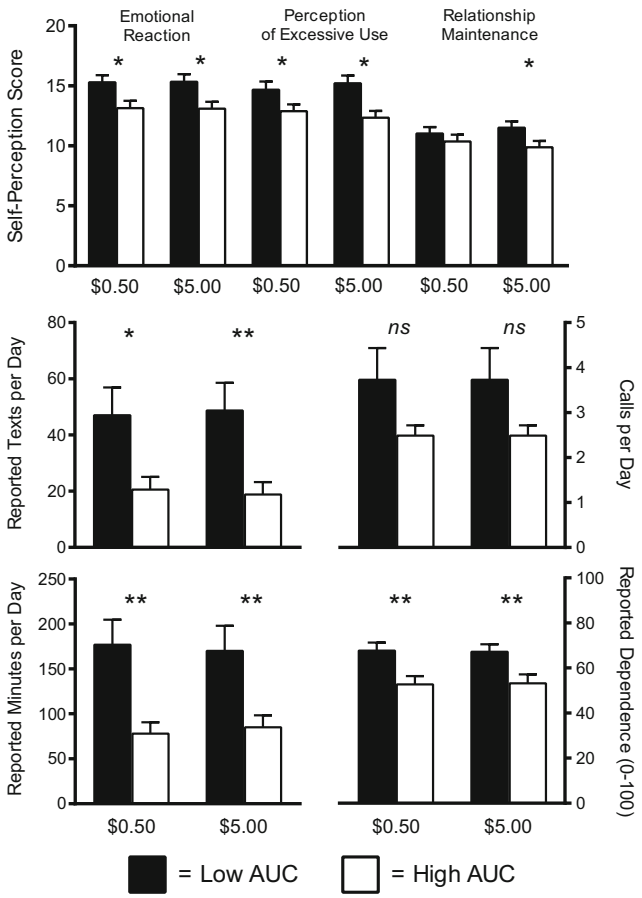

Fig. 3 Top panel depicts group differences on the three Self-Perception of Text Message Dependency factors for low (black bars) and high (white) AUC groups. The bottom four panels depict group differences on four items from our questionnaire relating to cellular phone use adapted from Billieux et al. (2007). All error bars indicate *SEM*. *$p < .05$. **$p < .01$. ^{ns} $p > .05$

Finally, we sought to compare the AUC groups on behavioral indicators of text messaging and cellular phone dependence from our questionnaire relating to cellular phone use adapted from Billieux et al. (2007). The $0.50 low-AUC group reported writing 47.00 text messages per day ($SEM = 9.90$), which was significantly greater than the 20.55 text messages per day ($SEM = 4.54$) in the $0.50 high-AUC group, $t(109) = 2.42$, $p < .05$. Similarly, the $5.00 low-AUC group reported writing 48.70 text messages per day ($SEM = 9.85$) whereas the $5.00 high-AUC group reported writing 18.82 text messages per day ($SEM = 4.43$), $t(109) = 2.75$, $p = .007$. The $0.50 low-AUC group also reported using significantly greater minutes of cellular phone time ($M = 177.04$, $SEM = 27.85$) than the $0.50 high-AUC group ($M = 78.05$, $SEM = 12.78$), $t(109) = 3.21$, $p < .01$. Similar results were found for the $5.00 condition with the low-AUC group reporting significantly greater minutes of cellular phone usage ($M = 170.10$, $SEM = 28.00$) than the high-AUC group ($M = 85.13$, $SEM = 13.37$), $t(109) = 2.72$, $p = .008$. Significantly greater overall cellular phone dependence was reported in the $0.50 low-AUC group ($M = 67.73$, $SEM = 3.52$) compared to the $0.50 high-AUC group ($M = 52.69$, $SEM = 3.78$), $t(109) = 2.91$, $p = .004$. Results for the $5.00 group were similar with the low-AUC group reporting significantly greater dependence ($M = 67.20$, $SEM = 3.31$) than the high-AUC group ($M = 53.24$, $SEM = 4.01$), $t(109) = 2.69$, $p = .008$. Finally, while the $0.50 low-AUC group reported higher numbers of calls per day ($M = 3.73$, $SEM = 0.70$) than the $0.50 high-AUC group ($M = 2.49$, $SEM = 0.23$), this difference merely approached significance, $t(109) = 1.67$, $p = .10$. The same was true for the $5.00 group with the low-AUC group reporting an average of 3.73 ($SEM = 0.70$) calls per day and the high-AUC group reporting 2.50 ($SEM = 0.23$) calls per day, $t(109) = 1.67$, $p = .10$. A visual summary of these findings is shown in the bottom panels of Fig. 3.

Discussion

Nearly all (90 %) American adults own a cellular phone, with 81 % of users reporting regular text messaging, making text messaging the highest reported cellular phone activity (Pew

Internet Project, 2014). Indeed, 100 % of our Amazon Mechanical Turk sample ($N = 111$) reported owning a cellular phone, underscoring adult reliance on this technology in today's digital world. However, the reinforcing properties of cellular phone text messaging may account for the boom in text-messaging prevalence, leading researchers to consider cellular phone use a form of addictive behavior (Billieux et al., 2007). The goal of this study was to consider text messaging within the framework of delay discounting as a marker of behavioral addiction (Bickel et al., 2011a, b, 2012, 2014; Jarmolowicz et al., 2015). As such, we sought to develop and validate a behavioral economic task (DDTQ) to quantify text-messaging dependence characteristics within a delay discounting framework, using a relatively cross-sectional crowdsourced sample on Amazon Mechanical Turk.

The DDTQ expanded on an existing text-messaging discounting task by Atchley and Warden (2012). Specifically, we adapted the procedure to render it more in line with commonly used delay discounting tasks (see Madden & Bickel, 2010). We subsequently validated the DDTQ by examining its degree of systematic discounting according to criterion 1 of Johnson and Bickel's (2008) algorithm and sensitivity to a common discounting manipulation—magnitude—known to modulate rates of discounting.[2] Finally, we examined the ability of the DDTQ to discriminate different profiles of possible text-messaging dependence. The DDTQ was successful in all three aims, suggesting it is a viable task for use in studies examining the behavioral economics of possible text-messaging dependence.

Notwithstanding the conceptual and methodological contributions of this study, a number of limitations remain, tempering our conclusions and guiding future refinements. First, behavioral economic considerations of addiction incorporate both demand and discounting as behavioral economic markers of addictive behavior. The DDTQ focuses solely on discounting and does not address demand. Future research must integrate the DDTQ with demand for text messaging to fully render text-messaging dependence within a behavioral economic framework.

Second, our use of a crowdsourced Amazon Mechanical Turk workforce may have provided a biased sample of technologically savvy adults that may contain a higher base rate of cellular phone use and possible dependence than the general population. Other researchers report, however, that the Amazon Mechanical Turk workforce is substantially more representative of the American public than the convenience samples typically used in academic research (e.g., university or community samples; see Paolacci & Chandler, 2014).

Third, our use of a VAS is fairly novel for a delay discounting task and lacks the degree of validation inherent in other forms of delay discounting. Recent studies have successfully used VAS procedures to yield systematic delay discounting of sexual outcomes (with adequate psychometrics; Herrmann, Hand, Johnson, Badger, & Heil, 2014; Johnson, Johnson, Herrmann, & Sweeney, 2015; Johnson & Bruner, 2012, 2013) and environmental decisions (Kaplan, Reed, & McKerchar, 2014).

Fourth, the DDTQ does not assess *actual* intertemporal tradeoffs of text messaging and relies exclusively on self-report within a hypothetical vignette. Much research has shown that hypothetical delay discounting tasks yield similar rates of discounting using real rewards (e.g., Johnson & Bickel, 2002; Bickel, Pitcock, Yi, & Angtuaco, 2009; Lagorio & Madden, 2005; Madden, Begotka, Raiff, & Kastern, 2003; Madden et al., 2004; Matusiewic, Carter, Landes, & Yi, 2013), assuaging this concern. Nevertheless, there are some examples where hypothetical and nonhypothetical nonmonetary outcomes yield different discounting rates (see R. M. Green & Lawyer, 2014), warranting additional investigation with text messaging. Finally, the recent advances in classifying addictive disorders in the *DSM-5* (American Psychiatric Association, 2013), such as gambling disorder, warrant translation to text messaging-dependence within behavioral economic models.

Taken together, the results of this study suggest the DDTQ is a valid and potentially useful tool for examining behavioral economic markers of a text-messaging dependence profile within a behavioral economic (specifically, delay discounting) model of addictive behavior. This tool should be used with other validated measures of addictive behavior until further psychometric evaluation is documented. In the absence of further psychometric evaluation, the DDTQ can provide researchers with a unique behavioral indicator of text-messaging dependence.

[2] The astute reader will note, however, that this magnitude effect is observed with rewarding outcomes, not losses (see Estle et al., 2006; McKerchar, Pickford, & Robertson, 2013; Mitchell & Wilson, 2010). Our DDTQ may be considered a cross-commodity task combining both gains (texting immediacy) and losses (monetary payments), rending extrapolation of existing literature to the DDTQ rather difficult. Future research should isolate such variables to better understand the basic decision-making processes underlying delay discounting of text messaging.

Compliance with Ethical Standards

Conflict of Interest None.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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