

Words Matter: Implementing the Electronically Activated Recorder in Schizotypy

Kyle S. Minor<sup>1\*</sup>, Bashaun J. Davis<sup>1</sup>, Matthew P. Marggraf<sup>1</sup>, Lauren Luther<sup>1</sup>, Megan L. Robbins<sup>2</sup>

<sup>1</sup>Department of Psychology, Indiana University- Purdue University Indianapolis, Indianapolis, IN, United States

<sup>2</sup>Department of Psychology, University of California – Riverside, Riverside, CA, United States

\*Corresponding Author: K. S. Minor; IUPUI School of Science, Department of Psychology, LD 124, 402 N. Blackford St., Indianapolis, IN, 46202; Phone: (317) 274 -2933; Fax: (317) 274-6756; email: [ksminor@iupui.edu](mailto:ksminor@iupui.edu)

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*Keywords:* electronically activated recorder, ecological momentary assessment, schizotypy, negative affect, lexical analysis.

### **Abstract**

In schizophrenia-spectrum populations, analyzing the words people use has offered promise for unlocking information about affective states and social behaviors. The Electronically Activated Recorder (EAR) is an application-based program that is combined with widely used smartphone technology to capture a person's real-world interactions via audio recordings. It improves upon the ecological validity of current methodologies by providing objective, naturalistic samples of behavior. This study is the first to implement the EAR in people endorsing elevated traits of schizophrenia-spectrum personality disorders (i.e., schizotypy) and we expected the EAR to: 1) Differentiate high and low schizotypy groups on affective disturbances and social engagement; and 2) Show that high schizotypy status moderates links between affect and social behavior using a multi-method approach. Lexical analysis of EAR recordings revealed greater negative affect and decreased social engagement in those high in schizotypy. When assessing specific traits, EAR and ecological momentary assessment (EMA) converged to show that positive schizotypy predicted negative affect. Finally, high schizotypy status moderated links between negative affect and social engagement when the EAR was combined with EMA. Adherence did not influence results, as both groups wore the EAR over 90% of their waking hours. Findings supported using the EAR to assess real-world expressions of personality and functioning in schizotypy. Evidence also showed that the EAR can be used alongside EMA to provide a mixed-method, real-world assessment that is high in ecological validity and offers a window into the daily lives of those with elevated traits of schizophrenia-spectrum personality disorders.

*Keywords:* electronically activated recorder, ecological momentary assessment, schizotypy, negative affect, lexical analysis.

Analyzing the words people use has offered promise for unlocking information about their affective states and social behaviors (Buck, Minor, & Lysaker, 2015; Fineberg et al., 2016; Minor, Marggraf, Davis, Mehdiyoun, & Breier, 2016). In schizophrenia-spectrum populations, affective disturbances and reduced social engagement extend to schizotypy—a construct that affects approximately 10% of the population and reflects elevated traits of schizophrenia-spectrum personality disorders (Lenzenweger, 2006; Meehl, 1962; 1990; Morton et al., 2017). In those high in schizotypy, affective disturbances are often exhibited by greater negative affect and less positive affect compared to one's peers (Barrantes-Vidal, Chun, Myin-Germeys, & Kwapil, 2013; Najolia, Cohen, & Minor, 2009); reduced social engagement is demonstrated through less engagement in social situations (Kwapil, Brown, Silvia, Myin-Germeys, & Barrantes-Vidal, 2012; Minor & Cohen, 2010). Typically, affective disturbances and social engagement are assessed with interview-rated or performance-based measures in a laboratory setting (Mausbach, Moore, Bowie, Cardenas, & Patterson, 2009). However, laboratory measures are limited by retrospective bias; assessment at one-time point; and a lack of focus on context (Barrantes-Vidal et al., 2013; Myin-Germeys & van Os, 2007). Thus, assessments of affective disturbances and social engagement often lack ecological validity and may not translate to real-world situations.

One strategy for addressing the limitations of laboratory-based assessments has been to implement ecological momentary assessment (EMA)—a method of collecting multiple 'in-the-moment' appraisals outside of the laboratory (Gard, Sanchez, Cooper, Fisher, Garrett, & Vinogradov, 2014; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001). EMA increases ecological validity by providing subjective behavioral accounts in real-world settings. However, these accounts can be affected by many of the same concerns afflicting self-report instruments (e.g., social desirability, arbitrary ratings, limited conscious awareness). Since EMA

is not designed to collect objective accounts of affective disturbances or social engagement, there is a need to integrate it with a methodology that can yield objective behavioral samples from daily life. An objective measure would allow examiners to pair observed behaviors from one's environment with behavioral measurement systems—such as lexical analysis—to monitor real-world situations for affective disturbances and social engagement.

The Electronically Activated Recorder (EAR), an application-based computer program that is combined with widely used smartphone technology (e.g., iPod Touch, iPhone) to capture a person's natural environment via audio recordings, is a methodology well-suited to provide behavioral samples from daily life. In EAR studies, subjects wear a device running the EAR application in a carrying case outside of their clothing, making it visible yet unobtrusive for most daily activities. This allows for direct observation of real-world behaviors while accounting for many limitations of subjective measurement (Mehl, Robbins, & Deters, 2012; Robbins, Mehl, Holleran, & Kastle, 2011b). To restrict social desirability bias, subjects are unaware of when EAR recordings occur. To reduce the effects of arbitrary ratings, samples are rated using objective metrics (e.g., lexical analysis; see Mehl et al., 2012). To address diminished awareness, researchers analyze behaviors outside of conscious awareness (e.g., affective word use). Pairing the EAR with EMA has the mutual benefit of addressing potential concerns of objective assessment by giving voice to participant's interpretations of events and collecting data when few behavioral signals are present (see Table 1 for a comparison of methods). Together, the EAR and EMA can increase ecological validity while providing internal and external accounts of real-world situations. To date, no study has used the EAR in a schizophrenia-spectrum population.

[INSERT TABLE 1 HERE]

In studies involving healthy and psychiatric populations, EAR data has demonstrated feasibility (Mehl, Gosling, & Pennebaker, 2006; Mehl, Vazire, Holleran, & Clark, 2010), test-retest reliability (Mehl & Pennebaker, 2003), and split-half reliability (Mehl, Vazire, Ramirez-Esparza, Slatcher, & Pennebaker, 2007). Studies have also indicated that EAR data diverge from subjective ratings (Mehl et al., 2007; Ramirez-Esparza, Mehl, Ovarez-Bermudez, & Pennebaker, 2009) but show strong links between behaviors (e.g., swearing, sighing) and psychological constructs (e.g., poor social engagement, depression) when paired with lexical analysis (Robbins, Focella, Kasle, Lopez, Weihs, & Mehl, 2011a; Robbins et al., 2011b). In this study, we merged the EAR with: 1) Lexical analysis to yield objective ratings of affective disturbances and social engagement; and 2) EMA to offer a window into participant's internal and external worlds. Given that EMA has shown how negative affect is increased and positive affect and social engagement are decreased in schizotypy (Kwapil et al., 2012), a multi-method strategy combining the EAR with EMA holds potential to reduce shared method variance while illustrating links between affective disturbances and social engagement in daily life.

### **Objectives and Hypotheses**

In this study, we had two primary aims and one secondary aim. The first primary aim was to use EAR and EMA approaches to determine if high and low schizotypy groups differed in affect or social engagement. Across methods, we expected those with schizotypy to exhibit less positive affect, greater negative affect, and less social engagement. A secondary aim was to test if positive, negative, or disorganized traits were associated with affective disturbances or social engagement using the EAR. These post-hoc analyses were conducted in light of a previous EMA study showing that positive and negative schizotypy have differing relationships with affect and

social engagement (Kwapil et al., 2012). Our second primary aim was to assess if EAR and EMA methods could be combined to illustrate whether high schizotypy status moderated relationships between affect (i.e., low positive, high negative) and social engagement. Previous studies have shown how schizotypy explains links between affective and social variables (Husky, Grondin, & Swendsen, 2004; Kwapil et al., 2012). By testing these aims, this study offers a rigorous assessment of real-world functioning that can provide snapshots of the internal and external lives of those at increased risk for schizophrenia-spectrum personality disorders.

## Method

### Participants

All participants were undergraduates at a Midwestern university recruited in three stages (see Figure 1). Experimental credit and/or cash was given to compensate participants for their time. Inclusion was dependent on participants: a) Providing valid responses to four Chapman Infrequency scale items (Chapman & Chapman, 1983); b) Meeting criteria for the high schizotypy (> 95<sup>th</sup> percentile on positive, negative, and/or disorganized schizotypy) or low schizotypy group (< 50<sup>th</sup> percentile in overall schizotypy) on an online schizotypy questionnaire (responses controlled for sex and ethnicity); c) Having no previous psychotic disorder diagnosis; and d) Having both EAR and EMA data. Similar methodologies are commonly used in the schizotypy literature (see Cohen, Auster, McGovern, & MacAulay, 2014; Minor, Cohen, Weber, & Brown, 2011). In total, 46 people participated in the EAR/EMA study (high schizotypy  $n = 25$ , low schizotypy  $n = 21$ ; see Figure 1), which was offered to subjects as a separate study after they completed laboratory testing. No significant differences were observed in age, sex, race, ethnicity, overall schizotypy, positive schizotypy, negative schizotypy, or disorganized

schizotypy when comparing EAR study participants to those who only participated in the lab study (all  $p$ 's > 0.55). Within the high schizotypy group, 21 participants were > 95<sup>th</sup> percentile on only one schizotypy trait (7 positive, 8 negative, 6 disorganized) and 4 were > 95<sup>th</sup> percentile on multiple traits (1 positive / negative, 1 positive / disorganized, 1 negative / disorganized, 1 positive / negative/ disorganized). All procedures were approved by local institutional review boards.

[INSERT FIGURE ONE HERE]

## Measures

**Schizotypy Scale.** The Schizotypal Personality Questionnaire (SPQ; Raine, 1991) was the online study questionnaire. Identifying people based on responses to schizotypy questionnaires has shown positive links to future onset of psychotic disorders and schizophrenia-spectrum personality disorders (Cohen & Najolia, 2011; Gooding, Tallent, & Matts, 2005; Kwapil, Miller, Zinser, Chapman, & Chapman, 1997). The SPQ consists of 74 questions separated into positive, negative, and disorganized factors (Raine, Reynolds, Lencz, Scerbo, Triphon, & Kim, 1994). All questions ranged from 1 (Strongly Disagree) to 5 (Strongly Agree).

**Electronically Activated Recorder.** The EAR (Mehl et al., 2012) is an application that is combined with widely used smartphone technology to capture a person's natural environment via audio recordings. It has exhibited strong parallel test reliability, test-retest reliability, and discriminant validity from self-reported behavior (Mehl et al., 2007; Mehl & Robbins, 2012). Studies have also shown that subtle behaviors (e.g., sighing) captured via the EAR can be linked

to psychological constructs (e.g., depression; Robbins et al., 2011b) and profane language in social situations—but not alone—predicts poor social support (Robbins et al., 2011a).

Following informed consent, participants were given information about the EAR. They were instructed to wear an iPod Touch running the EAR for two consecutive days during their waking hours; two days was chosen based on recommendations from the co-creator of the EAR (see Mehl et al., 2012) and findings that this length exhibited good temporal stability (Mehl & Robbins, 2012). While wearing the device, five-minute audio recordings were made at pre-programmed intervals up to twelve times per day (from 6:00a.m. to 12:00a.m.)—resulting in up to two hours of audio data per participant. The sampling rate was chosen to provide behavioral data during different periods of the day that were long enough to capture situational context. Devices were locked and participants were unaware of when recordings occurred. EAR devices had signs alerting others that recordings may occur (i.e., ‘This device is being used for research purposes. It records nearby surroundings at various intervals and may record your voice’). Upon returning devices, participants completed a nine-item experiential questionnaire (Mehl, Pennebaker, Crow, Dabbs, & Price, 2001; see Table 1). To reduce privacy concerns, participants were given the option of listening to and deleting audio files before providing access to the research team. Consistent with previous studies, less than 1% of files were deleted (Robbins et al., 2011a; Robbins, Lopez, Weihs, & Mehl, 2014).

Remaining audio files were transcribed and analyzed. Studies have found valid ratings can be made on EAR recordings  $\geq 20$  seconds (Mehl et al., 2012). Analyses conducted by our team included objective ratings of adherence using ambient sounds and lexical analysis of speech from EAR recordings. Sounds files were judged to be valid and waking when ambient sounds were present (e.g., speech, movement, coughing, breathing). Lexical analysis was conducted on

valid sound files using the Linguistic Inquiry Word Count (LIWC; Pennebaker, Booth, Boyd, & Francis, 2015), a computerized measure that uses an internal dictionary to calculate percentages for 98 separate categories. The LIWC has exhibited good validity for measuring verbal emotional expression (Kahn, Tobin, Massey, & Anderson, 2007) and has previously been used to assess word use in schizophrenia-spectrum populations (Fineberg et al., 2016; Minor et al., 2015a; Najolia et al., 2009). In this study, we focused on three LIWC categories: 1) Positive emotion (to assess positive affect); 2) Negative emotion (negative affect); and 3) Word count from subject (social engagement). For affective analyses, recordings had to contain  $\geq 50$  words from subjects to provide a representative sample. For social engagement, words were only analyzed when spoken to another person (i.e., self-talk was excluded). Word count was used to measure social involvement because it provides a proxy for how engaged subjects were during interactions (e.g., weighs files where subjects speak throughout differently than files where subjects give 1-2 short responses).

**Ecological Momentary Assessment.** EMA ratings were conducted two ways: 1) Via a take-home social journal; and 2) By answering phone calls from research personnel (see supplemental online material). Social journals were completed using paper and pencil for each waking hour over the same two-day period participants wore devices with the EAR. Phone calls were made approximately five times per day and immediately followed a scheduled EAR recording (i.e., data was only recorded if the call occurred within 15 minutes of the EAR recording; most calls occurred within five minutes of the end of the recording). Ratings were made at similar time points so that data could be compared at similar time points. We used social journals in addition to the phone call approach to ensure sufficient data for analyses with the EAR and to account for potential limitations with each EMA methodology. Both forms of EMA

asked participants to describe their current activity, assessed current EAR adherence, and asked participants to rate their current levels of positive and negative affect (e.g., 1 = no positive feelings, 7 = extremely positive feelings).

## Results

### Demographic, Adherence, and Experiential Data

Groups did not significantly differ in age, sex, race, ethnicity, or EAR/EMA adherence. Two significant, but opposing, group differences were found on EAR experiential questions. Compared to the low schizotypy group, those high in schizotypy estimated that other people discussed the EAR less,  $t(44) = 2.11, p = 0.040$ , but changed their behavior more as a result of the EAR,  $t(44) = -2.13, p = 0.039$ . Post-hoc analyses showed that negative schizotypy traits were associated with less discussion of the EAR by others,  $r(46) = -0.44, p = 0.002$ . No other significant group differences were found (Table 2).

[INSERT TABLE TWO HERE]

When testing overlap between the EAR and EMA, non-significant to small correlations were observed when using social journals, Positive affect:  $\rho(241) = -0.05, p = 0.447$ ; Negative affect:  $\rho(241) = 0.14, p = 0.035$ , or phone calls as the EMA methodology, Positive affect:  $\rho(53) = 0.13, p = 0.362$ ; Negative affect:  $\rho(53) = -0.04, p = 0.788$ . When testing overlap between the two different EMA approaches, moderate to strong correlations were observed, Positive affect:  $\rho(188) = 0.49, p < 0.001$ ; Negative affect,  $\rho(188) = 0.60, p < 0.001$ . Overall, analyses showed

little overlap between the EAR and EMA measures and significant convergence for the two EMA approaches during the same time point.

### **EAR and EMA Data as Predicted by High Schizotypy Status**

Multilevel modeling tested whether high schizotypy status predicted affective disturbances or social engagement. This approach allowed for examination of how scores/behaviors varied as a function of being nested within individuals (Level 1) and groups (Level 2). In models analyzing affect, sex was controlled for based on findings that males (greater negative affect) and females (greater positive affect) differ in self-reported affect and affective word use (Brody & Hall, 2000; St-Hilaire, Cohen, & Docherty, 2008). Measured via the EAR, the high schizotypy group used a significantly greater frequency of negative affect words,  $\gamma = -0.46$ ,  $SE = 0.24$ ,  $p = 0.035$ , and exhibited less social engagement,  $\gamma = 29.58$ ,  $SE = 13.05$ ,  $p = 0.014$ , than the low schizotypy group (Table 3). There were no group differences in positive affect word use,  $\gamma = 0.26$ ,  $SE = 0.48$ ,  $p = 0.298$ . Findings supported our hypothesis that the high schizotypy would exhibit less real-world social engagement and partially supported hypotheses that the EAR could be used to show real-world differences in affective disturbances.

[INSERT TABLE THREE HERE]

EMA also showed greater negative affect in the high schizotypy compared to low schizotypy group using both social journals,  $\gamma = -0.57$ ,  $SE = 0.26$ ,  $p = 0.016$ , and phone calls,  $\gamma = -0.45$ ,  $SE = 0.21$ ,  $p = 0.019$  (Figure 2). No differences in positive affect were found with social

journal,  $\gamma = 0.22$ ,  $SE = 0.31$ ,  $p = 0.238$ , or phone call approaches,  $\gamma = 0.13$ ,  $SE = 0.26$ ,  $p = 0.310$ .

These findings were in line with the EAR results and partially supported our hypotheses.

[INSERT FIGURE TWO HERE]

### **EAR and EMA Data as Predicted by Specific Schizotypy Traits**

Post-hoc multilevel analyses were conducted to determine the role of specific schizotypy traits in predicting real-world negative affect and social engagement. Positive schizotypy traits were a significant predictor of greater negative affect when measured using the EAR,  $\gamma = 0.25$ ,  $SE = 0.11$ ,  $p = 0.027$ , social journals,  $\gamma = 0.25$ ,  $SE = 0.12$ ,  $p = 0.041$ , and phone call approaches,  $\gamma = 0.22$ ,  $SE = 0.10$ ,  $p = 0.034$ . Negative schizotypy traits predicted greater negative affect using social journals,  $\gamma = 0.32$ ,  $SE = 0.10$ ,  $p = 0.003$ , but not EAR,  $\gamma = 0.07$ ,  $SE = 0.10$ ,  $p = 0.530$ , or phone call methodologies,  $\gamma = 0.18$ ,  $SE = 0.09$ ,  $p = 0.058$ . Disorganized traits did not significantly predict negative affect using EAR,  $\gamma = 0.17$ ,  $SE = 0.11$ ,  $p = 0.124$ , social journal,  $\gamma = 0.20$ ,  $SE = 0.12$ ,  $p = 0.089$ , or phone call approaches,  $\gamma = 0.15$ ,  $SE = 0.10$ ,  $p = 0.147$ .

Regarding social engagement, significant relationships were not observed with positive schizotypy,  $\gamma = -4.17$ ,  $SE = 6.23$ ,  $p = 0.508$ , negative schizotypy,  $\gamma = -6.72$ ,  $SE = 5.28$ ,  $p = 0.210$ , or disorganized schizotypy,  $\gamma = -8.67$ ,  $SE = 5.70$ ,  $p = 0.135$ , using the EAR approach. Overall, EAR and EMA methodologies both illustrated that positive schizotypy traits predicted greater levels of negative affect. Partial support was provided for the role of negative schizotypy in predicting negative affect. Significant relationships were not found for any of the three types of schizotypy traits in predicting social engagement.

### **High Schizotypy Status as a Moderator for Links Between Affective Disturbances and Social Engagement**

A mixed-methods approach was implemented to determine if high schizotypy status moderated relationships between: a) Positive affect and social engagement; and b) Negative affect and social engagement. For each expected outcome, two separate multilevel models were constructed using the EAR to assess social engagement and EMA to measure affect (Model 1: Social journal; Model 2: Phone calls). Using phone calls from study personnel, a trend level association was observed between negative affect and social engagement,  $\gamma = -14.06$ ,  $SE = 8.92$ ,  $p = 0.059$ , with social engagement declining as greater negative affect was endorsed. High schizotypy status was a significant moderator of this relationship,  $\gamma = 26.60$ ,  $SE = 15.48$ ,  $p = 0.044$ . This indicates that the inverse relationship between negative affect and social engagement strengthens when one is in the high schizotypy, as opposed to low schizotypy, group. As illustrated using PROCESS (Hayes, 2012; see Figure 3), schizotypy status determines the type of relationship between negative affect and social engagement. People low in schizotypy became more socially engaged when negative affect was greater, whereas those high in schizotypy were less socially engaged when negative affect was greater.

[INSERT FIGURE THREE HERE]

Positive affect was not associated with social engagement when phone calls were used as the EMA methodology,  $\gamma = 4.85$ ,  $SE = 8.75$ ,  $p = 0.290$ . High schizotypy status did not have a significant effect on this relationship,  $\gamma = 7.80$ ,  $SE = 13.31$ ,  $p = 0.279$ . When social journals were used, no association with social engagement was observed for positive,  $\gamma = 3.44$ ,  $SE = 3.91$ ,  $p =$

0.190, or negative affect,  $\gamma = -4.63$ ,  $SE = 4.27$ ,  $p = 0.139$ . Schizotypy status did not moderate relationships between social engagement and positive,  $\gamma = 7.23$ ,  $SE = 6.09$ ,  $p = 0.118$ , or negative affect,  $\gamma = 1.14$ ,  $SE = 7.06$ ,  $p = 0.436$ , in these analyses. Our hypothesis that a mixed-methods approach would show that schizotypy moderates relationships between affect and social engagement were not supported for positive affect and partially supported for negative affect.

### **Discussion**

In this study, our primary goal was to determine if the EAR could be implemented to provide objective data on affective disturbances and social engagement in schizotypy. Four key findings emerged. First, high and low schizotypy groups did not differ in EAR adherence. Second, lexical analysis using EAR recordings illustrated how those high in schizotypy exhibited more negative affect words and demonstrated less social engagement in daily life. Third, positive schizotypy traits predicted greater negative affect using EAR and EMA methodologies. Fourth, we were able to successfully integrate the EAR with EMA to create real-world models via a multi-method approach. Through this approach, evidence emerged for the moderating role of schizotypy in explaining links between negative affect and social engagement.

In line with previous studies, participants wore EAR devices over 90% of their waking hours and deleted less than 1% of EAR recordings (Robbins et al., 2011a; Robbins, Lopez, Weihs, & Mehl, 2014). Participants reported that wearing the EAR did not generally affect their daily activities and had little effect on their behavior; conflicting group differences emerged regarding their perceptions of other's behavior. Compared to the low schizotypy group, those high in schizotypy reported less discussion of the EAR device by other people but perceived a greater impact on other's behavior due to the EAR. These findings likely reflect the greater level

of negative schizotypy traits and less social engagement that were observed in the high schizotypy group. Previous studies have shown that people habituate to wearing the EAR after a few hours (Mehl & Holleran, 2007; Mehl et al., 2012). However, those with greater negative schizotypy reported less discussion of the EAR by others and people in the high schizotypy group were less socially engaged compared to the low schizotypy group. Both of these factors may have given others less time to habituate to the device and, in turn, affected how perceptions of their behavior changed in response to the EAR.

This is the first schizotypy study to use objective data from the EAR to illustrate group differences in negative affect and social engagement—supporting data from previous laboratory and EMA studies (Barrantes-Vidal et al., 2013; Cohen & Davis, 2009; Kwapil et al., 2012; McCleery et al., 2012; Minor & Cohen, 2010). Our findings are notable given the EAR's potential of providing an objective, real-world assessment that may be less affected by positive impression management, the arbitrary nature of subjective ratings, or limits of one's conscious awareness (Mehl et al., 2012). Our observation that those high in schizotypy exhibit less social engagement might hold important clinical implications. Social impairments often develop early in the course of psychosis and are reflected through poor communication and few social connections (Bowie & Harvey, 2008; Cornblatt et al., 2012; Minor et al., 2015b; Minor et al., 2016); these impairments are a key criterion for predicting which people expressing high-risk traits will transition to full psychotic symptoms (Allen, Frantom, Strauss, & van Kammen, 2005; Cannon et al., 2001; Cornblatt et al., 2012). To better understand the clinical significance of our finding, future work using the EAR should assess social engagement longitudinally to determine if it declines over time—as well as whether potential declines lead to greater risk of psychosis.

Regarding affective disturbances, EAR findings for negative affect were in line with EMA results from this and other schizotypy studies (Barrantes-Vidal et al., 2013; Kwapil et al., 2012). Post-hoc analyses revealed that positive schizotypy traits were a significant predictor of greater negative affect using all three types of real-world methods. The convergence of these three approaches supports previous EMA findings (Kwapil et al., 2012) and suggests that the greater suspiciousness and ideas of reference (i.e., positive traits) endorsed by the schizotypy group is significantly associated with greater levels of negative affect. A previous EMA study has also found evidence that negative schizotypy is linked to greater negative affect and reduced positive affect (Kwapil et al., 2012). Negative schizotypy's role was less clear in our results, with limited support for its role in negative affect (i.e., evidence was found using one of three approaches) and no relationship found between schizotypy status and positive affect. To our knowledge this was the first study to test how disorganized schizotypy predicted real-world negative affect or social engagement; however, no significant relationships were observed.

Despite reaching similar overall conclusions regarding affective disturbances, there was little overlap between the EAR and EMA. This likely reflects how these two real-world measures tap into different facets of daily life. Whereas the EAR provides researchers with a way to examine affect without relying on a participant's interpretations, EMA can add important context (e.g., conversation setting, social relationships) and allow for measurement when no environmental signal is present. Thus, each approach offers unique advantages. Ideally, the EAR and EMA could be integrated to supply researchers with a more comprehensive understanding of a participant's natural environment. This strategy holds potential for creating a multi-method assessment that is high in ecological validity; can be implemented in real-world settings; and is unaffected by shared method variance. Future research could also benefit from using mobile

sensing, an emerging methodology that represents a third form of real-world data collection (Ben-Zeev et al., 2016; Boase & Ling, 2013; Wrzus, Brandmaier, von Oertzen, Müller, Wagner, & Riediger, 2012). Whereas the EAR is designed to explore content within social interactions using auditory stimuli, mobile sensing is optimal for logging specific behaviors through smartphone-based technology (e.g., movement through Global Positioning Systems, proximity to speech via .wav files). It has not been used to date in schizotypy but a recent study from Ben-Zeev and colleagues (2016) demonstrated that it is a feasible, acceptable, and informative method for collecting real-world behaviors in schizophrenia.

Using a mixed-methods approach consisting of EAR and EMA data, schizotypy status was shown to moderate relationships between negative affect (measured via EMA) and social engagement (measured with the EAR). Links became stronger when negative affect increased, with those in the high schizotypy group exhibiting a significant drop in social engagement. The low schizotypy group showed the opposite effect—greater negative affect increased the likelihood of social engagement. One potential explanation that is supported by previous findings in the schizotypy literature (Horan, Brown, & Blanchard, 2007; MacAulay & Cohen, 2013) is that the two groups may use opposing coping strategies whenever negative affect is experienced: The low schizotypy group may be more likely to seek social engagement, whereas those high in schizotypy could be more likely to disengage. In line with this finding, a previous EMA study found that those high in schizotypy rated social situations as less pleasant than a low schizotypy group (Kwapil et al., 2012). It should be noted that this moderating effect was only observed using phone calls from study personnel. Although the phone call approach more closely resembles traditional EMA strategies, it was surprising that moderation was not observed with

social journals. Other explanations could also exist for the observed finding; for example, social engagement is just as likely to influence negative affect since causality was not tested here.

The use of both objective and subjective real-world measures was a significant strength of this study. Assessing affect and social engagement in participant's natural environments with lexical analysis was also an important strength. One limitation of the current study is the small sample size, which raises questions regarding replicability. Offering the EAR as a separate study instead of integrating it within the laboratory study was likely a contributing factor to the low recruitment numbers. A related limitation centers on the sampling methodology and use of an undergraduate population. We employed a commonly used approach of recruiting undergraduate students based on endorsement of one of three traits (positive, negative, disorganized) to reflect the heterogeneity present in schizotypy (Cohen et al., 2014; Minor et al., 2011). However, it may also lead to generalizability concerns (see Zhang & Brenner, 2017), as our study failed to find links between negative schizotypy and affect that have been observed in a previous EMA study which recruited separate positive and negative schizotypy subgroups (Kwapil et al., 2012). EAR results observed should be considered preliminary and followed up in future studies with larger samples. A third limitation is that no EMA measure of social engagement was implemented and devices were not employed for EMA assessments of affect. Although we used two approaches to assess affect, there are meaningful disadvantages to phone call (e.g., lower response rates) and social journal (e.g., no assurance that ratings were conducted 'in-the-moment') strategies. A fourth limitation is that EMA measures may have influenced observable behaviors by increasing participant's awareness of the EAR. We measured this effect via the experiential questionnaire and participant's reported little influence of the EAR on their behavior. As we have discussed, however, subjective reports are often limited and these limitations may affect the accuracy of

participant's ratings. Additionally, the questionnaire did not touch on whether EMA influenced behavior. Future work should test the effect of EMA experimentally by assigning participants to engage in both EAR / EMA and EAR only conditions—and randomizing the order of conditions.

In sum, lexical analysis of EAR recordings effectively detected real-world differences in negative affect and social engagement in those high in schizotypy. When assessing the role of specific traits, EAR and EMA methods converged to illustrate how positive schizotypy predicted negative affect. Using a mixed-methods approach, we found evidence for the moderating role of schizotypy in explaining links between negative affect and social engagement. Findings suggest that the EAR can be used alongside EMA to create an assessment high in ecological validity that is unaffected by shared method variance. Future work should test the utility of the EAR at other points on the schizophrenia-spectrum and replicate our results in a larger schizotypy sample to give a more comprehensive understanding of real-world behaviors in those expressing elevated traits of schizophrenia-spectrum personality disorders.

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Table 1

*Comparing Different Methods of Assessing Affective Disturbances and Social Engagement*

	<b>Interview-rated</b>	<b>Performance-based</b>	<b>EMA</b>	<b>EAR</b>
<b>Approach</b>	Laboratory	Laboratory	Ecological	Ecological
<b>Mode</b>	Active	Active	Active	Passive
<b>Assessment of</b>	Subjective account	Virtual interactions	Self-perceptions	Social interactions
<b>Method</b>	Rating of self-report	Task performance	Self-report	Observed behavior
<b>Perspective</b>	Internal and external	External	Internal	External
<b>Awareness</b>	High	Moderate	High	Low once habituated
<b>Data collection</b>	Examiner rates scale	Examiner scores task	Subject rates scale	Behaviors analyzed
<b>Strengths</b>	Widely used with good psychometric data for many measures; Time and cost efficient	Objective method of rating behavior based on task performance; Time efficient; Typically standardized	Multiple ratings across days/times; High ecological validity; Subject is an expert on their own experiences	Multiple samples across days/times; High ecologically validity; Captures real-world behavior outside of awareness
<b>Weaknesses</b>	Retrospective bias; Lack of situational context; Reliance on self-report affects those low in insight	Difficult to simulate tasks that resemble real-world situations; Unable to tailor to person's experiences	Social desirability; Arbitrary scales; Many behaviors are outside conscious awareness	Many ratings cannot be made without behavioral signal; Relies on subject wearing device

*Note.* EMA = Ecological Momentary Assessment; EAR = Electronically Activated Recorder.

Adapted with permission from Mehl (2007).

Table 2

*Demographic and Adherence Data in High and Low Schizotypy Groups*

Demographic data	High Schizotypy ( <i>n</i> = 25)			Low Schizotypy ( <i>n</i> = 21)		
	Mean	SD	Range	Mean	SD	Range
Age	19.92	2.14	18 – 27	19.81	1.86	18 – 25
Female (%)		64.00			47.62	
Non-Hispanic Caucasian (%)		64.00			76.19	
SPQ <i>z</i> -scores						
Total***	1.41	0.64	-0.34 – 3.27	-0.65	0.33	-1.33 – -0.01
Positive***	1.09	0.98	-1.48 – 2.41	-0.45	0.40	-1.21 – 0.53
Negative***	1.33	0.92	-0.65 – 3.03	-0.72	0.50	-1.71 – 0.57
Disorganized***	1.27	0.92	-1.15 – 3.16	-0.56	0.44	-1.58 – 0.13
EAR adherence						
Total recordings	15.92	3.63	6 – 24	16.95	4.33	7 – 24
Time wearing device (%)	91.73	9.30	65 – 100	91.09	12.86	50 – 100
Audio files deleted (%)	0.28	1.02	0 – 26.32	0.62	1.02	0 – 14.29
EMA adherence						
Total social journal ratings	17.24	3.96	6 – 22	18.19	4.17	6 – 24
Total phone call ratings	3.92	2.41	1 – 9	4.24	2.36	1 – 8
Phone call response rate (%)	53.99	28.79	20 – 100	46.83	24.85	10 – 88.89
EAR experiential questions						
General awareness	3.08	0.81	1 – 5	3.05	0.92	1 – 5
Discomfort	1.96	1.06	1 – 4	1.62	0.92	1 – 4

Impedes daily activities	1.44	0.87	1 – 4	1.29	0.56	1 – 3
Change in behavior	1.56	0.82	1 – 4	1.29	0.46	1 – 3
Influenced way of talking	1.36	0.76	1 – 4	1.38	0.81	1 – 4
Other's awareness	2.88	1.13	1 – 5	3.43	1.12	1 – 5
Device discussed by others*	2.96*	1.14	1 – 5	3.57	0.75	1 – 5
Change in other's behavior*	2.16*	1.03	1 – 4	1.57	0.81	1 – 4
Represents typical day	3.92	1.00	2 - 5	4.10	0.89	2 – 5
Estimated time with EAR (%)	86.67	11.39	40 – 100	85.14	21.06	5 – 100

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*Note.* Adherence data reflects recordings/responses during waking hours; EAR experiential questions were scored using the following scale: 1 = not at all, 2 = between not at all and somewhat, 3 = somewhat, 4 = between somewhat and a great deal, 5 = a great deal.

SD = standard deviation; % = percentage; SPQ = Schizotypal Personality Questionnaire; EAR = Electronically Activated Recorder; EMA = Ecological Momentary Assessment.

\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

Table 3

*Electronically Activated Recorder (EAR) and Ecological Momentary Assessment (EMA) Data in High and Low Schizotypy Groups*

EAR	High Schizotypy ( $n = 25$ )			Low Schizotypy ( $n = 21$ )		
	Mean	SD	Range	Mean	SD	Range
Positive affect word use (%)	3.65	2.55	0 – 11.20	3.88	2.44	0 – 11.20
Negative affect word use (%)*	1.93	1.65	0 – 6.13	1.53	1.41	0 – 5.77
Social engagement*	43.44	96.62	0 – 675	74.65	124.23	0 – 723
<b>EMA</b>						
Social journal: Positive affect	4.65	1.60	1 – 7	4.99	1.45	1 – 7
Phone calls: Positive affect	5.31	1.29	1 – 7	5.38	1.17	1 – 7
Social journal: Negative affect*	2.38	1.46	1 – 7	1.84	1.21	1 – 7
Phone calls: Negative affect*	2.02	1.23	1 – 7	1.64	0.92	1 – 5

*Note.* Social engagement measured as average words per valid waking recording. SD = standard deviation; % = percentage. \*  $p < 0.05$ .

**FIGURE LEGENDS**

*Figure 1.* Participant flow chart.

*Figure 2.* Real-world negative affect in high and low schizotypy groups over the course of daily life using: A) The Electronically Activated Recorder to measure negative affect word use; B) Ecological momentary assessment via social journals to measure negative affect; and C) Ecological momentary assessment via phone calls from study personnel to measure negative affect.

*Figure 3.* Schizotypy status moderates the relationship between negative affect and social engagement when phone calls from study personnel are used to measure negative affect and the Electronically Activated Recorder is used to assess social engagement. Illustration of this moderation effect was created using PROCESS for SPSS (Hayes, 2012).

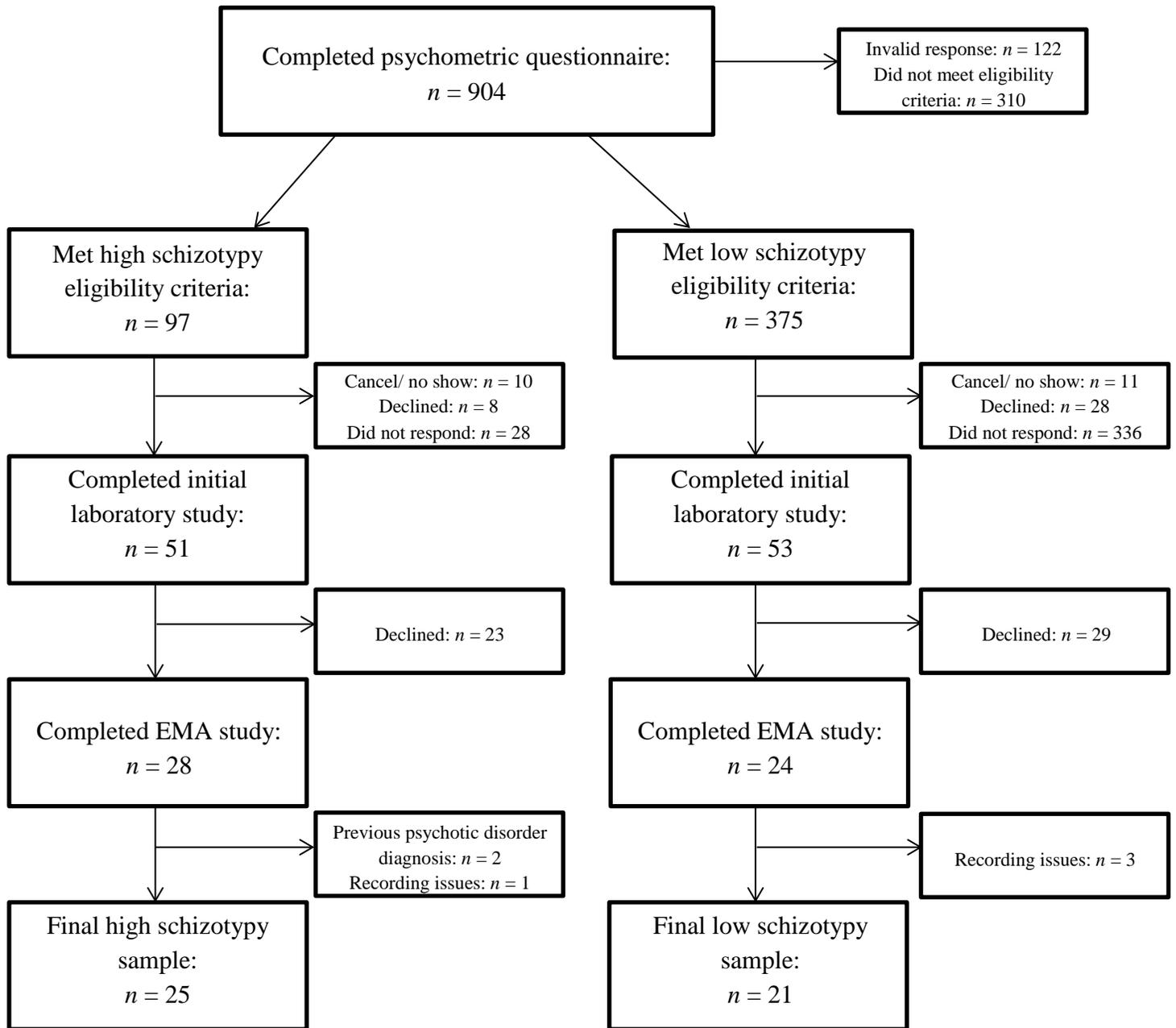


Figure 1. Participant flow chart.

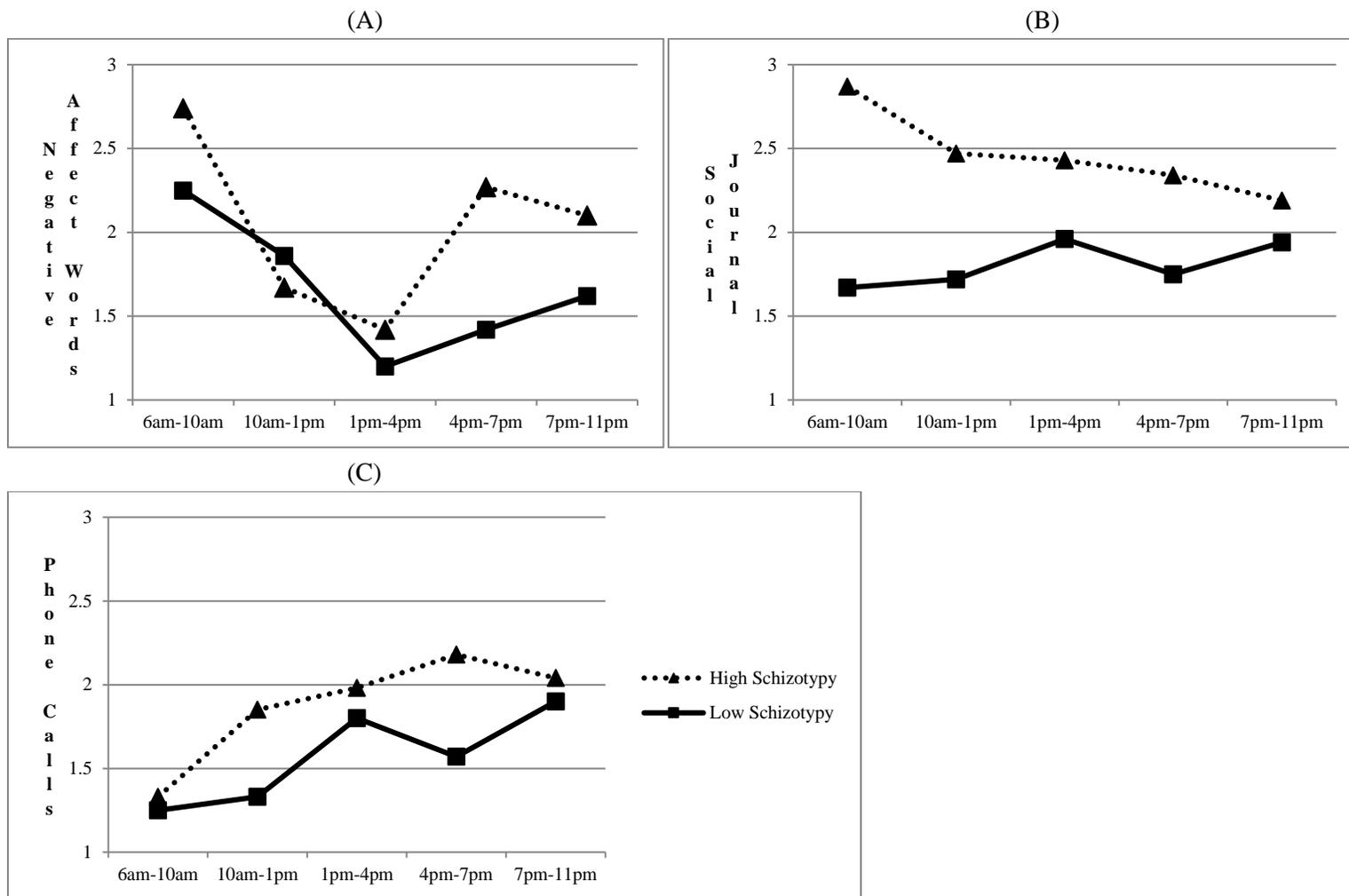
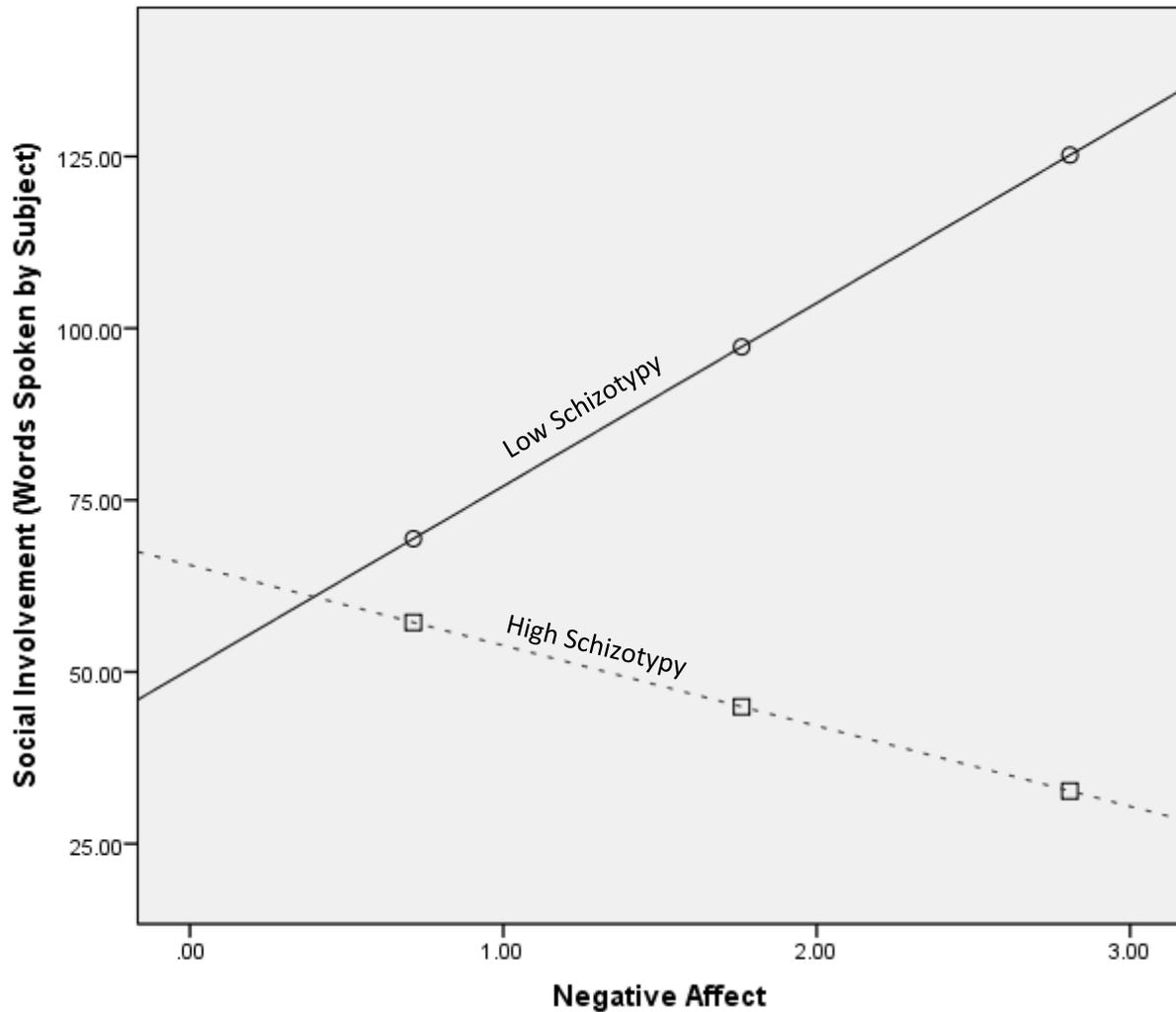


Figure 2. Real-world negative affect in high and low schizotypy groups over the course of daily life using: A) The Electronically Activated Recorder to measure negative affect word use; B) Ecological momentary assessment via social journals to measure negative affect; and C) Ecological momentary assessment via phone calls from study personnel to measure negative affect.



*Figure 3.* Schizotypy status moderates the relationship between negative affect and social involvement when phone calls from study personnel are used to measure negative affect and the Electronically Activated Recorder is used to assess social involvement. Illustration of this moderation effect was created using PROCESS for SPSS (Hayes, 2012).