

Original Research

## Examining the Social Signaling and Person Perception Functions of Loneliness

Kory Floyd<sup>1,\*</sup>, Nathan Woo<sup>1</sup>, Benjamin Custer<sup>2</sup>, Dana Dinsmore<sup>1</sup>, Kaylin Duncan<sup>1</sup>, Jeannette Maré<sup>1</sup>

1. Department of Communication, University of Arizona, Tucson AZ USA; E-Mails: [koryfloyd@arizona.edu](mailto:koryfloyd@arizona.edu); [nathantwoo@email.arizona.edu](mailto:nathantwoo@email.arizona.edu); [danadinsmore@email.arizona.edu](mailto:danadinsmore@email.arizona.edu); [kduncan7@email.arizona.edu](mailto:kduncan7@email.arizona.edu); [jmare@email.arizona.edu](mailto:jmare@email.arizona.edu)
2. Fulbright Program, Plovdiv University, Plovdiv, Bulgaria; E-Mail: [becuster@email.arizona.edu](mailto:becuster@email.arizona.edu)

\* **Correspondence:** Kory Floyd; E-Mail: [koryfloyd@arizona.edu](mailto:koryfloyd@arizona.edu)**Academic Editor:** Ami Rokach**Special Issue:** [The Many Shades of Loneliness](#)*OBM Neurobiology*

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### Abstract

Loneliness is a common condition that poses substantial risks to morbidity and mortality. Cacioppo and Cacioppo's [1] evolutionary theory of loneliness (ETL) provides that loneliness serves a social signaling function and also manifests in hypervigilance to threat, which we propose can influence person perception. In this experiment, 480 observers evaluated videotaped self-presentation messages from speakers who scored either high or low on a measure of loneliness. On the basis of ETL, we hypothesized that observers can distinguish between lonely and non-lonely speakers to a greater-than-chance degree and that observers' own loneliness negatively influences their perceptions of speakers. Both predictions received support, and we identify both theoretic and potential clinical implications of these findings.

### Keywords

Loneliness; social signaling; perception; personality; attraction



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## **1. Examining the Social Signaling and Person Perception Functions of Loneliness**

Humans are a supremely social species whose well-being is determined in part by the strength and quality of their social relationships. When individuals perceive a discrepancy between their desired and achieved levels of social connection—a condition known as loneliness—they are susceptible to detriments in their health and well-being irrespective of their marital or parental status, frequency of contact with friends, participation in social or religious groups, or other objective markers of social engagement [2].

Loneliness is such an adverse condition that social scientists have long wondered what possible advantages it affords. Why would a tendency to experience loneliness have evolved in the human species, and why does it persist? The present study takes a functionalist approach to addressing these questions by exploring two potential communicative functions of loneliness: to serve as a social signal and to influence person perception. This review begins with a description of loneliness and of Cacioppo and Cacioppo's evolutionary theory of loneliness. We then explore its potential social signaling function and its potential effects on perceptions of others' dispositions and attractiveness.

### **1.1 Loneliness**

Loneliness is an aversive psychological state stemming from the perception that the quality and quantity of an individual's interpersonal relationships are insufficient to meet one's needs [3]. Loneliness can affect individuals of all ages, but all age groups are not similarly susceptible. Several studies have indicated that prevalence rates for loneliness are highest among two groups: adolescents and young adults [4, 5] and the elderly [6, 7]. Although these groups experience loneliness more frequently than others, situational factors, particularly social and temporal contexts, have been shown to influence the prevalence and severity of loneliness as a momentary state across groups [8, 9].

Trait loneliness, on the other hand, is characterized by subjective thoughts, feelings, and perceptions related to social isolation, and much of our understanding of loneliness and its detrimental associations with mental health and physical wellness has relied on operationalizing loneliness as a trait [1]. Lonely individuals are more depressed [10], more stressed [11], and less psychologically resilient [12] than their non-lonely counterparts. Lonely individuals also experience impaired sleep [13], increased pain [14], and increased risks of cardiovascular disease [15], coronary heart disease [16], and Alzheimer disease-like dementia in later life [17]. Moreover, loneliness is a risk factor for both suicide ideation [18] and attempted suicide [19] and is a predictor of all-cause mortality [6, 20, 21]. Understandably, loneliness has been deemed a public health crisis in the United States [22, 23] and elsewhere in the world [24, 25].

Because loneliness is such an aversive experience, social scientists have struggled to understand why it evolved in the human species and why it persists. One explanation is offered in the evolutionary theory of loneliness, described subsequently.

### **1.2 Loneliness from an Evolutionary Perspective**

Cacioppo and Cacioppo's [1] evolutionary theory of loneliness (ETL) takes an explicitly adaptationist perspective to explain the prevalence of loneliness in terms of its contributions to the

superordinate evolutionary motivations of survival and procreation. Specifically, ETL proposes that the experience of loneliness 1) signals that valuable social relationships are endangered and 2) makes the lack of social connection physically and psychologically aversive so that 3) individuals are prompted to generate or restore such relationships. Because social inclusion facilitates both individual survival and reproductive opportunity relative to social exclusion, according to ETL, humans have evolved a genetically based predisposition to feel lonely when they perceive that the quality or quantity of their social connections are insufficient [26]. Two functions of loneliness, in particular, are relevant to appreciating this claim. First, loneliness serves a social signaling function, wherein it alerts the individual—and, we contend conspecifics—that salutary social ties are endangered. Second, loneliness initiates a perception of vulnerability and a hypervigilance to threat that—as we propose in the present study—has a detrimental effect on person perception. Both functions are detailed subsequently.

### **1.3 The Social Signaling Function of Loneliness**

Humans depend on a wide array of social signals to make sense of the world around them. Poggi and D’Errico [27] defined a *signal* as “any perceivable stimulus from which a system can draw some meaning” and a *social signal* as “a communicative or informative signal which, either directly or indirectly, provides information about ‘social facts,’ that is, about social interactions, social attitudes, social relations and social emotions” (p. 189). Seemingly detrimental affective and physiological states—such as pain [28], fear [29], and depression [30]—are nonetheless adaptive, in part because they signal distress to conspecifics in ways that can elicit aid. Watson and Andrews’s [31] social navigation hypothesis, for instance, provides that depression serves an honest signaling function that can persuade social partners to render assistance and/or to make concessions to the depressed individual. To function effectively, however, social signals must be readily interpretable. For instance, signals of aversive affective states such as sadness or fear can have information value to observers—and elicit helpful behavioral responses as a result—only if they are accurately and reliably decoded [32].

This evolutionary signaling function is analogous to the innate tendency to enact distress calls when an organism is in danger, a propensity observed among human neonates [33], as well as among other mammals [34] and other animals [35-38]. ETL provides that loneliness evolved, in part, “to serve as a signal that one’s connections to others are frayed or broken and to motivate the repair and maintenance of the connections to others that are needed for our health and well-being as well as for the survival of our genes” [39]. ETL explicitly claims that loneliness can function as an intrapersonal signal of distress to the lonely individual himself or herself, motivating corrective action [1]. We propose that it also serves as an interpersonal/social signal to conspecifics, eliciting social and emotional support (see, e.g., Hawkley & Cacioppo [40]). This argument has been explicitly advanced as an explanation for the etiology of major depressive disorder [30], and although loneliness and depression are empirically distinct states [41], they share considerable conceptual space, leading us to advance a similar argument here.

Are traits such as loneliness accurately assessed by others? Some research has demonstrated this effect for personality traits. Agreeableness and extraversion, for example, can be accurately assessed by observers [42, 43], even when observers and targets are strangers [44] and even if observers’ assessments are made entirely on the basis of photographs [45] or social media profiles

[46]. Agreeableness and extraversion are *external traits* characterized by highly visible behavioral patterns [47]. Loneliness, in contrast, is an *internal trait*. As Luhmann et al. [48] pointed out, however, internal traits are not completely unobservable; they simply manifest themselves in fewer observable cues than do external traits.

If loneliness is adaptive in part because it signals distress, then it stands to reason that observers should be able to discriminate lonely from non-lonely individuals to a greater-than-chance degree after some level of social exposure. Some evidence shows this to be the case with observers who are already familiar with the target. Mearns et al. [49] asked 74 college students to rate their own loneliness and then to have a roommate, friend, or parent also rate the students' loneliness. Self- and informant-ratings of the students' loneliness were positively related,  $r = 0.44$ . Due in part to the small sample size of the Mearns et al. study, Luhmann et al. [48] replicated the procedure by obtaining self-reported loneliness scores from 463 young adult participants and then asking the participants' friends, parents, and romantic partners to rate the participants' loneliness. Participants' self-reported loneliness scores were positively correlated with those provided by friends,  $r = 0.37$ ; by parents,  $r = 0.43$ ; and by romantic partners,  $r = 0.66$ . Romantic partners' assessments were more strongly correlated with participants' self-reports than were the assessments made by friends or parents, the latter two of whom did not differ from each other.

These results and others illustrate that those who know someone well can accurately report on that person's level of loneliness [50]. We contend that ETL's claim of a signaling function for loneliness also implies that observers can accurately identify loneliness even when the target is a stranger and observers have exposure only to minimal social cues. We thus hypothesize:

H1: Observers can discriminate lonely from non-lonely speakers.

We recognize, too, that observers' own loneliness may affect how likely they are to recognize loneliness in others. On one hand, it may be the case that lonely observers have heightened empathic accuracy for loneliness [51], giving them an advantage for identifying loneliness in others. On the other hand, multiple studies have shown that loneliness impairs the ability to interpret social cues accurately (Floyd & Woo [52]; Kanai et al. [53]; but see Cacioppo et al. [54]), which would disadvantage lonely individuals attempting to recognize loneliness in others. We therefore ask:

RQ1: Does observers' own loneliness moderate the effect of loneliness condition on observers' perceptions of speakers' loneliness?

#### **1.4 Person Perception: Effects of Observers' Loneliness**

The current study also examines the possibility that observers' own loneliness influences their perceptions of speakers, irrespective of the speakers' loneliness. ETL's implicit vigilance postulate proposes that loneliness causes feelings of vulnerability and initiates hypervigilance to threat. Because their need to belong is so pronounced [55] and because social exclusion meant a dangerous lack of resources in their evolutionary past [56], humans feel more defenseless and susceptible to harm when they are lonely, according to ETL. In line with this proposal, loneliness has been shown to covary with impaired sleep [13], excessive alcohol use [57], and heightened cardiovascular responses to stressors [58]. Similarly, loneliness heightens sensitivity to threatening social cues [59], including facial expressions of negative emotions such as fear and sadness [60].

One effect of such hypervigilance may be that loneliness increases individuals' tendency to perceive others—especially strangers or those they do not know well—as more threatening and to evaluate them more negatively. Some research has found that when people assess hypothetical others, their own loneliness predicts more negative evaluations of others [61] and of their communication [62, 63]. Similarly, in actual interactions with strangers, loneliness predicted negative views of interaction partners, albeit for men only (Jones et al. [64]; but see Christensen & Kashy [65]). Similar effects of loneliness have been identified when people report on others they know [66, 67], although Tsai and Reis [68] found that loneliness predicted somewhat more positive assessments of acquaintances than of friends.

The present study applies the logic of the implicit vigilance postulate to the task of predicting how observers' loneliness influences their perceptions of speakers. Given that loneliness heightens vigilance to threat, we propose that observers' loneliness predicts more negative evaluations of speakers. We apply this general prediction to three outcomes. First, we hypothesize that loneliness increases the tendency to view speakers as lonely, net of the effects of speakers' actual loneliness.

H2: Observers' loneliness is directly associated with their perception of speakers' loneliness.

Second, we propose that loneliness negatively influences observers' perceptions of others. If lonely people are hypervigilant to threat, we expect this to manifest in less benevolent assessments of others' fundamental tendencies. Given the empirical support in the literature that demonstrates strangers can accurately assess two of the big five personality traits (i.e., extraversion and agreeableness) of complete strangers at a greater-than-chance degree [44] in conjunction with the implicit vigilance postulate, we predict that loneliness distorts observers' perceptions of others' personality. Models and conceptualizations of what personality entails vary drastically [68]. One of the most prevalent and widely used conceptualizations of personality in the social sciences is the five-factor model (a.k.a, the big five; Goldberg [69]; McCrae & John [70]). In addition to extraversion and agreeableness, the three other broad dimensions of personality that comprise the five-factor model are conscientious, emotional stability (sometimes referenced by its opposite, neuroticism), and openness to experience. All five traits are correlated with positive personal values and assessments [71, 72] and are desired in others [73]. On the basis of ETL, we therefore hypothesize that the lonelier observers are, the lower their likelihood of attributing these qualities to others.

H3: Observers' loneliness is inversely associated with their perceptions of speakers' a) extraversion, b) agreeableness, c) conscientiousness, d) emotional stability, and e) openness.

As ETL predicts and as multiple studies have found, loneliness leads to more negative assessments of others. Finally, if loneliness promotes wariness of others and initiates hypervigilance, as the implicit vigilance postulate suggests, we propose that increased wariness and more negatively skewed assessments of others have implications for perceived attractiveness, as forming impressions of how attractive we perceive others to be is a fundamental and automatic perceptual process for humans [74]. Attraction, like, personality, is multifaceted. McCroskey and McCain [75] conceptualized interpersonal attraction as comprising three elements: a) physical attraction, or attraction to one's appearance; b) social attraction, or attraction to one's personality; and c) task attraction, or attraction to one's abilities. Using this conceptualization of attraction, we predict that loneliness will covary with impaired assessments of others' attractiveness along these dimensions.

H4: Observers' loneliness is inversely associated with their perceptions of speakers' a) physical attractiveness, b) social attractiveness, and c) task attractiveness.

Ultimately, the present study aims to experimentally test our theoretically derived predictions, which hypothesize that observers can distinguish between lonely and non-lonely speakers to a greater-than-chance degree and that observers' own loneliness negatively influences their perceptions of speakers who are complete strangers. Our experimental method is subsequently presented.

## 2. Method

### 2.1 Participants

Participants ( $N = 480$ ) were 273 men, 206 women, and 1 who did not report a gender identity who ranged in age from 18 to 74 years ( $M = 42.09$  years,  $SD = 10.68$ ). With respect to ethnicity, 3.8% of participants identified as Hispanic and 96.2% identified as non-Hispanic. With respect to race, 81% of participants identified as white, 10% as Black/African American, 6.5% as Asian/Pacific Islander, 1% as Latino/a, 1% as Native American or Aleut, 0.2% as Arab, and 0.6% as having other racial backgrounds.<sup>1</sup> Participants represented 44 of 50 U.S. states plus the District of Columbia.

### 2.2 Creation of Experimental Stimuli

Participants each watched one videotaped message featuring either a lonely or non-lonely speaker. Creation of the video messages occurred in two phases. In the first phase, 653 undergraduate students in communication courses were prescreened for loneliness. There were 247 men, 397 women, 2 transgender individuals, and 7 individuals who did not report a gender identity ranging in age from 18 to 37 years old ( $M = 19.98$  years,  $SD = 2.16$ ). Most (73%) identified as white, whereas 8.3% were Latino/a, 8.1% were Black/African American, 7.5% were Asian/Pacific islander, 1.7% were Arab, 1.1% were Native American or Aleut, and 1.8% claimed other racial origins. 17.6% of participants identified as Hispanic and 82.4% identified as non-Hispanic. Each student completed the 20-item Revised UCLA Loneliness Scale [76], McDonald's  $\omega = 0.93$ .<sup>2</sup>

Loneliness scores were calculated and divided into quintiles. From the highest and lowest quintiles each, 12 women and 12 men were randomly selected and invited to participate in a brief laboratory procedure. Those who declined were replaced with randomly selected alternates from the same quintile.

In the second phase, the 48 randomly selected students (24 men and 24 women, hereafter referred to as *speakers*) representing the highest and lowest quintiles on loneliness participated individually in a brief laboratory procedure. The speakers ranged in age from 18 to 34 years old ( $M = 20.42$  years,  $SD = 2.81$ ). Most (71.2%) identified as white, whereas 9.6% were Asian/Pacific islander; 9.6% were black/African American, 3.8% were Latino/a, and 1.9% claimed other racial origins. 19.2%

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<sup>1</sup> These percentages sum to > 100 because some participants reported more than one racial background.

<sup>2</sup> Although Cronbach's alpha is a commonly reported measure of internal reliability, recent research has advocated substituting McDonald's omega ( $\omega$ ), which is Cronbach's alpha's parent measure [77]. Unlike alpha, McDonald's omega does not assume essential tau-equivalence, which [78] explains is the assumption that "each item measures the same latent variable, on the same scale, but with possibly different degrees of precision" (p. 934).

of participants identified as Hispanic and 80.8% identified as non-Hispanic. The 48 speakers represented 16 distinct academic majors.

Speakers in the high-loneliness group scored significantly higher on loneliness ( $M = 5.49$ ,  $SD = 0.98$ ) than did participants in the low-loneliness group ( $M = 1.74$ ,  $SD = 0.58$ ), Welch's  $t(40.72) = -16.78$ ,  $p$  (one-tailed)  $< 0.001$ , Cohen's  $d = 0.81$ .<sup>3</sup> Loneliness did not differ as a function of sex, with women's average loneliness score ( $M = 3.62$ ,  $SD = 2.16$ ) nearly identical to men's ( $M = 3.61$ ,  $SD = 2.00$ ), Welch's  $t(42.70) = 0.02$ ,  $p$  (two-tailed)  $= 0.98$ ,  $d = 0.004$ . There was no interaction between sex and condition on loneliness scores. Loneliness was not significantly correlated with speakers' age,  $r(46) = -0.12$ ,  $p$  (two-tailed)  $= 0.40$ .

Each speaker was seated in front of a computer monitor and was read the following instructions verbatim.

In a few minutes, what I'm going to ask you to do is imagine you're creating a personal ad, but instead of making an ad for a new romantic partner, you'll be advertising for a new *friend*. Think about how you could introduce yourself, what you might say about yourself, and what you might say about the kinds of qualities you are seeking in a friend. In a minute, I'm going to leave the room and I'll ask you to record your personal ad for a new friend. When you're ready to record, all you have to do is click on this red "Camera" button. When you do, you'll see a countdown of 3, 2, 1, and then the software will start recording. The camera is at the top of the computer screen, next to the green light. You can say anything you would like in your personal ad, and you can talk for as little or as long as you like. Remember that the goal of your ad is to talk about yourself and what you seek in a friend. The only thing I'm going to ask is that you not say your name out loud, so that your identity remains confidential.

Subsequently, the researcher left the room and speakers recorded their self-presentation messages. The speaker notified the researcher after the video message was finished. Speakers were then debriefed, paid \$20US, and dismissed.

Speakers were asked to record a personal ad for a friend, as opposed to a romantic partner, to avoid confounds for those who were in a romantic relationship at the time. Speakers were never informed that they had been selected because of their loneliness score, so they were blind to the experimental condition. To ensure that speakers' verbal self-presentation would not prime observers to attend to the speakers' loneliness, we examined the transcripts of their videos for any instances of the terms *lonely*, *loneliness*, and *lonelier*, and no instances were found.

### **2.3 Procedure**

All procedures were approved by the university's institutional review board. Participants were recruited via the Amazon.com crowdsourcing marketplace Mechanical Turk (MTurk), an online venue where more than 250,000 workers perform functions provided by companies or organizations in exchange for payment in the form of money or Amazon.com gift cards. For the present study, a work assignment—called a *hit* on MTurk—was created in which providers were asked to take part in a survey about social behavior. Those who elected to participate clicked on a

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<sup>3</sup> Welch's  $t$ -test is increasingly preferred to Student's  $t$ -test because of its more stable Type I error rate and greater robustness to violations of normality and homogeneity of variance [79]. Additionally, Welch's  $t$ -test outperforms Student's  $t$ -test when sample sizes are unequal, and when data meet the homoscedasticity assumption, Welch's  $t$ -tests loses minimal robustness compared to the Student's  $t$ -test.

link to an online questionnaire. At the conclusion of the questionnaire, participants received a code to enter on the MTurk site to verify their completion of the task. Participation was limited to providers 18 years of age or older who qualified as MTurk “masters” (indicating consistently high-quality work) and who had completed at least 100 previous hits with an approval rating of or exceeding 90%. Participants received \$1.25US in exchange for filling out the questionnaire, which took the average participant 11 minutes, 53 seconds to complete. Research has found that samples recruited on MTurk for academic research are often more representative of the U.S. population than are in-person convenience samples [80, 81].

The experimental video messages were uploaded to a secure online location. Participants in the MTurk sample were randomly assigned to view one video message. Participants were told that “the person shown in the video has been asked to record a ‘personal ad for a new friend,’” but they received no other information about the speaker and were blind to the loneliness manipulation.

After viewing their randomly assigned video message, participants were asked to report their perceptions of the speaker’s personality and disposition. Embedded within these items were items related to the speaker’s loneliness. Participants then reported on their own loneliness. As a manipulation check, participants were also asked whether they knew the speaker in the video message, on a five-point scale ranging from “not at all” to “very well.” Those who selected any response other than “not at all” were excluded.

An *a priori* power analysis [82] indicated that a sample size of 480 provides in excess of 90% power to identify small ( $f^2 = 0.02$ ) effect sizes in multiple regression, assuming  $\alpha = 0.05$  and two predictors (loneliness condition and observer loneliness).<sup>4</sup>

## 2.4 Measures

In these studies, we report all measures, manipulations, and exclusions. Participants were asked to indicate their perceptions of the speakers along multiple dimensions by indicating their level of agreement with a series of statements. *Observers’ perception of speakers’ loneliness* was assessed with four statements created for this study (“this person is lonely,” “this person is without close friends,” “this person is withdrawn and lacking companionship,” and “this person is isolated from others;”  $\omega = 0.94$ ).<sup>5</sup> A principal-components factor analysis with oblique rotation identified a single component containing all four items and accounting for 84.44% of the variance. *Personality* was measured with the short-form Big-Five personality dimensions scale [83], an extensively validated 10-item brief-form measure of extraversion ( $\omega = 0.81$ ), agreeableness ( $\omega = 0.68$ ), conscientiousness ( $\omega = 0.69$ ), emotional stability ( $\omega = 0.73$ ), and openness to experience ( $\omega = 0.58$ ).<sup>6</sup> *Attractiveness* was assessed with a 12-item version of the McCroskey and McCain [75] measure of interpersonal

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<sup>4</sup> 30 of the originally enrolled participants were excluded for failing an embedded attention check, 16 were excluded for providing an answer other than “not at all” to the question of whether they knew the speaker in the video, and 12 were excluded due to excessive missing data. We continued collecting data until our target sample size was achieved and no further deletions were necessary. No duplicate MTurk ID numbers appeared in the data file, and none of the remaining participants posted a time to completion of more than 2 standard deviations below the mean (see Litman & Robinson [84]).

<sup>5</sup> The decision not to use a longer validated loneliness scale—such as the UCLA Loneliness Scale—to measure participants’ perceptions of the speakers was made to conceal the focus on speakers’ loneliness by embedding a smaller number of items into a larger battery of items.

<sup>6</sup> We acknowledge that some of the reliability estimates for personality dimensions are suboptimal, likely as a function of the brief measure, which used only two items per dimension.



attraction, which assesses physical attraction ( $\omega = 0.93$ ), social attraction (or attraction to one's personality;  $\omega = 0.87$ ), and task attraction (or attraction to one's abilities;  $\omega = 0.80$ ).

Participants also reported on their own loneliness using the 20-item Revised UCLA Loneliness Scale (Russell et al. [76];  $\omega = 0.98$ ). Means, standard deviations, and intercorrelations for all participant measures appear in Table 1.

**Table 1** Descriptive Statistics and Intercorrelations for Study Variables (N = 480).

Variable	Min	Max	M	SD	1	2	3	4	5	6	7	8	9
1. Speaker lonely	1.00	9.00	3.77	2.14	--								
2. Extraversion	1.00	9.00	5.71	2.05	-0.52†	--							
3. Agreeableness	1.00	9.00	7.10	1.41	-0.29†	0.21†	--						
4. Conscientiousness	1.00	9.00	6.54	1.58	-0.31†	0.10*	0.48†	--					
5. Stability	1.00	9.00	6.48	1.66	-0.47†	0.22†	0.46†	0.57†	--				
6. Openness	1.00	9.00	6.05	1.72	-0.51†	0.37†	0.44†	0.25†	0.29†	--			
7. Physical attract	1.00	9.00	6.35	1.73	-0.22†	0.14†	0.31†	0.31†	0.31†	0.25†	--		
8. Social attract	1.00	9.00	6.66	1.61	-0.41†	0.25†	0.68†	0.49†	0.52†	0.51†	0.45†	--	
9. Task attract	1.00	9.00	6.82	1.52	-0.35†	-0.08	0.51†	0.65†	0.51†	0.37†	0.30†	0.59†	--
10. Observer lonely	1.00	9.00	3.47	1.92	0.16†	-0.08	-0.24†	-0.18†	-0.15†	-0.17†	-0.15†	-0.23†	-0.25†

Notes. \* $p < 0.05$  (two-tailed); † $p < 0.01$  (two-tailed).

### 3. Results

#### 3.1 Assessment of Potential Control Variables

Several variables were examined as potential control variables. Observers' perceptions of speakers' loneliness differed as a function of speaker sex, with male speakers ( $M = 4.04$ ,  $SD = 2.22$ ) being perceived as lonelier than female speakers ( $M = 3.50$ ,  $SD = 2.03$ ), Welch's  $t(474.44) = -2.74$ ,  $p$  (two-tailed) = 0.006,  $d = 0.25$ . Female speakers were perceived as more extraverted ( $M = 6.01$ ,  $SD = 1.99$ ) than were male speakers ( $M = 5.42$ ,  $SD = 2.08$ ), Welch's  $t(477.19) = 3.21$ ,  $p$  (two-tailed) = 0.001,  $d = 0.29$ . Female speakers were also perceived as more open ( $M = 6.26$ ,  $SD = 1.65$ ) than were male speakers ( $M = 5.83$ ,  $SD = 1.76$ ), Welch's  $t(476.25) = 2.75$ ,  $p$  (two-tailed) = 0.006,  $d = 0.25$ . Finally, female speakers were judged as more physically attractive ( $M = 6.83$ ,  $SD = 1.51$ ) than were male speakers ( $M = 5.88$ ,  $SD = 1.81$ ), Welch's  $t(464.18) = 6.27$ ,  $p$  (two-tailed) < 0.001,  $d = 0.57$ . The sex of the speaker had nonsignificant effects on all other outcomes.

The age of the speaker was correlated only with physical attractiveness,  $r(478) = -0.10$ ,  $p$  (two-tailed) = 0.037. Observers' sex produced no significant effects on any of the outcome variables, and observers' age was correlated only with observers' perceptions of speakers' agreeableness,  $r(477) = 0.12$ ,  $p$  (two-tailed) = 0.01, and speakers' physical attractiveness,  $r(477) = 0.12$ ,  $p$  (two-tailed) = 0.01.

To determine whether video length or word count required inclusion as a control variable, each video was professionally transcribed (Rev, Austin TX) and the transcripts were submitted to assessment using Pennebaker's Linguistic Inquiry and Word Count (LIWC) software, a highly validated computerized text analysis program (see Tausczik & Pennebaker [85]). Videos ranged in length from 14 to 369 seconds, with an average length of 98.29 seconds ( $SD = 81.02$ ). Word counts ranged from 29 to 1,283 words, with an average of 247.92 words ( $SD = 239.78$ ). As a measure of speech rate, we also calculated words-per-minute by dividing the video length in minutes by the word count. Words-per-minute ranged from 2.21 to 41.21, with an average of 23.94 ( $SD = 5.46$ ). These three variables were examined for potential correlations with the study's outcome variables.

Video length was significantly correlated only with observers' perceptions of speakers' openness,  $r(478) = 0.17$ ,  $p$  (two-tailed) < 0.001. Word count was also correlated only with observers' perceptions of speakers' openness,  $r(478) = 0.16$ ,  $p$  (two-tailed) < 0.001. Finally, words-per-minute was associated with observers' perceptions of speakers' loneliness,  $r(478) = 0.15$ ,  $p$  (two-tailed) = 0.001, and extraversion,  $r(478) = -0.13$ ,  $p$  (two-tailed) = 0.006.

#### 3.2 Hypotheses and Research Question

The first hypothesis predicted that observers can discriminate between lonely and non-lonely speakers at a greater-than-chance rate, and the research question asked whether the observers' own loneliness played a moderating role. H1 and RQ1 were addressed in a hierarchical multiple regression, with observers' perceptions of speakers' loneliness as the criterion variable. The first block of the regression contained the sex of the speaker (0 = male, 1 = female) and words-per-minute spoken in each speaker's video. The second block contained the speakers' loneliness condition (0 = non-lonely, 1 = lonely), and the third block contained the observers' own loneliness level, which was grand mean centered [86]. The final step contained an interaction term of loneliness condition and observers' loneliness. The interaction was nonsignificant, however, so it

was removed in the service of parsimony and the regression was recomputed with only the first three blocks. Collinearity diagnostics were unremarkable; VIF scores were  $\leq 1.09$  and tolerance scores were  $\geq 0.92$ . The regression produced a significant overall effect,  $F(4, 461) = 13.14, p < 0.001, \eta^2 = 0.10$ . As predicted by H1, observers perceived that speakers in the lonely condition were lonelier than speakers in the non-lonely condition,  $\beta = 0.22, p < 0.001$ . H1 is confirmed. As noted above, the loneliness condition-by-observer loneliness interaction was nonsignificant, so in response to RQ1, observer loneliness did not moderate the effect of loneliness condition on observers' perceptions of speakers' loneliness. Full regression results appear in Table 2.

**Table 2** Multiple Regression Predicting Observers' Perceptions of Speakers' Loneliness (N = 480).

Step	Variable	Zero-order <i>r</i>	B	SE B	$\beta$	$\Delta R^2$
1	Speaker sex	-0.12	-0.37	0.20	-0.09	0.029*
	Words per minute	0.15	0.05	0.02	0.12*	
2	Speaker sex	-0.12	-0.38	0.19	-0.09*	0.050†
	Words per minute	0.15	0.04	0.02	0.11*	
	Loneliness condition	0.26	0.94	0.19	0.22†	
3	Speaker sex	-0.12	-0.41	0.19	-0.10*	0.023*
	Words per minute	0.15	0.04	0.02	0.11*	
	Loneliness condition	0.26	0.90	0.19	0.21†	
	Observer loneliness	0.16	0.17	0.05	0.15*	

Notes.  $R^2 = 0.10$ ; adjusted  $R^2 = 0.10$ ;  $F(4, 461) = 13.14, p < 0.001$ . \* $p < 0.05$ ; † $p < 0.001$ . Observer loneliness was grand mean centered.

The second hypothesis predicted that observers' own loneliness is directly associated with their perceptions of speakers' loneliness. H2 was tested with the same regression used to test H1. As predicted, with the effect of speakers' loneliness condition controlled, the lonelier observers were, the lonelier they perceived the speakers to be,  $\beta = 0.15, p = 0.001$ . H2 is confirmed.

The third hypothesis predicted that observers' own loneliness is inversely associated with their perceptions of speakers' a) extraversion, b) agreeableness, c) conscientiousness, d) emotional stability, and e) openness. To test H3, separate regressions were conducted. In each regression, relevant control variables were entered in the first block and observers' loneliness (grand mean centered) was entered in the second block.

### 3.2.1 Extraversion

Speaker sex and words-per-minute were entered in the first block. In addition, speakers in the lonely condition ( $M = 6.08, SD = 1.96$ ) were judged as more extraverted than speakers in the non-lonely condition ( $M = 5.35, SD = 2.08$ ), Welch's  $t(476.32) = 3.90, p$  (two-tailed)  $< 0.001, d = 0.36$ , so loneliness condition was also entered in the first step. Observers' loneliness was entered in the second block. VIF scores were  $\leq 1.09$  and tolerance scores were  $\geq 0.92$ . The regression produced a significant overall effect,  $F(4, 461) = 9.93, p < 0.001, \eta^2 = 0.08$ . Contrary to the prediction, observer loneliness was not significantly related to speakers' perceived extraversion,  $\beta = -0.07, p = 0.11$ . H3a is not confirmed. Full regression results appear in Table 3.

**Table 3** Multiple Regression Predicting Observers’ Perceptions of Speakers’ Extraversion (N = 480).

Step	Variable	Zero-order <i>r</i>	B	SE B	$\beta$	$\Delta R^2$
1	Speaker sex	0.15	0.55	0.19	0.13*	0.074†
	Words per minute	-0.13	-0.03	0.02	-0.08	
	Loneliness condition	-0.18	-0.83	0.18	-0.20†	
2	Speaker sex	0.15	0.56	0.19	0.14*	0.005
	Words per minute	-0.13	-0.03	0.02	-0.08	
	Loneliness condition	-0.18	-0.81	0.18	-0.20†	
	Observer loneliness	-0.08	-0.08	0.05	-0.07	

Notes.  $R^2 = 0.08$ ; adjusted  $R^2 = 0.07$ ;  $F(4, 461) = 9.93, p < 0.001$ . \* $p < 0.05$ ; † $p < 0.001$ . Observer loneliness was grand mean centered.

### 3.2.2 Agreeableness

Observers’ age was entered in the first block and observers’ loneliness was entered in the second block. VIF scores were  $\leq 1.001$  and tolerance scores were  $\geq 0.99$ . The regression produced a significant overall effect,  $F(2, 463) = 19.71, p < 0.001, \eta^2 = 0.07$ . As predicted, observer loneliness was significantly related to speakers’ perceived agreeableness,  $\beta = -0.24, p < 0.001$ . H3b is confirmed. Full regression results appear in Table 4.

**Table 4** Multiple Regression Predicting Observers’ Perceptions of Speakers’ Agreeableness (N = 480).

Step	Variable	Zero-order <i>r</i>	B	SE B	$\beta$	$\Delta R^2$
1	Observer age	0.12	0.02	0.01	0.12*	0.014*
2	Observer age	0.12	0.02	0.01	0.12*	0.058†
	Observer loneliness	-0.24	-0.18	0.03	-0.24†	

Notes.  $R^2 = 0.07$ ; adjusted  $R^2 = 0.07$ ;  $F(2, 463) = 17.91, p < 0.001$ . \* $p < 0.05$ ; † $p < 0.001$ . Observer loneliness was grand mean centered.

### 3.2.3 Conscientiousness

There were no relevant control variables for conscientiousness, so a bivariate regression was used to test the prediction. The regression produced a significant overall effect,  $F(1, 464) = 16.23, p < 0.001, \eta^2 = 0.03$ . As predicted, observer loneliness was significantly related to speakers’ perceived conscientiousness,  $\beta = -0.18, p < 0.001$ . H3c is confirmed.

### 3.2.4 Emotional Stability

There were no relevant control variables for emotional stability, so a bivariate regression was used to test the prediction. The regression produced a significant overall effect,  $F(1, 464) = 10.24, p = 0.001, \eta^2 = 0.02$ . As predicted, observer loneliness was significantly related to speakers’ perceived conscientiousness,  $\beta = -0.15, p = 0.001$ . H3d is confirmed.

### 3.2.5 Openness

Speaker sex, video length, and words-per-minute were entered in the first block. In addition, speakers in the lonely condition ( $M = 6.33, SD = 1.55$ ) were judged as more open than speakers in the non-lonely condition ( $M = 5.76, SD = 1.82$ ), Welch's  $t(466.36) = 3.67, p$  (two-tailed)  $< 0.001, d = 0.34$ , so loneliness condition was also entered in the first step. Observers' loneliness was entered in the second block. VIF scores were  $\leq 4.27$  and tolerance scores were  $\geq 0.23$ .<sup>7</sup> The regression produced a significant overall effect,  $F(5, 460) = 9.25, p < 0.001, \eta^2 = 0.09$ . As predicted, observer loneliness was significantly related to speakers' perceived openness,  $\beta = -0.17, p < 0.001$ . H3e is confirmed. Full regression results appear in Table 5.

**Table 5** Multiple Regression Predicting Observers' Perceptions of Speakers' Openness (N = 480).

Step	Variable	Zero-order $r$	B	SE B	$\beta$	$\Delta R^2$
1	Speaker sex	0.13	0.51	0.16	0.15*	0.064†
	Video length	0.17	0.01	0.01	0.21*	
	Word count	0.16	0.01	0.01	-0.03	
	Loneliness condition	-0.17	-0.38	0.15	-0.11*	
2	Speaker sex	0.13	0.53	0.15	0.16*	0.027†
	Video length	0.17	0.01	0.01	0.20*	
	Word count	0.16	0.01	0.01	-0.02	
	Loneliness condition	-0.17	-0.34	0.15	-0.10*	
	Observer loneliness	-0.17	-0.14	0.04	-0.17†	

*Notes.*  $R^2 = 0.09$ ; adjusted  $R^2 = 0.08$ ;  $F(5, 460) = 9.25, p < 0.001$ . \* $p < 0.05$ ; † $p < 0.001$ . Observer loneliness was grand mean centered.

The fourth hypothesis predicted that observers' own loneliness is inversely associated with their perceptions of speakers' a) physical attractiveness, b) social attractiveness, and c) task attractiveness. To test H4, separate regressions were conducted. In each regression, relevant control variables were entered in the first block and observers' loneliness (grand mean centered) was entered in the second block.

### 3.2.6 Physical Attractiveness

Speaker sex, speaker age, and observers' age were entered in the first block and observers' loneliness was entered in the second block. VIF scores were  $\leq 1.12$  and tolerance scores were  $\geq 0.89$ . The regression produced a significant overall effect,  $F(4, 461) = 15.10, p < 0.001, \eta^2 = 0.12$ . As predicted, observer loneliness was significantly related to speakers' perceived physical attractiveness,  $\beta = -0.16, p < 0.001$ . H4a is confirmed. Full regression results appear in Table 6.

<sup>7</sup> Given the collinearity diagnostics, results of this regression should be interpreted with greater caution.

**Table 6** Multiple Regression Predicting Observers’ Perceptions of Speakers’ Physical Attractiveness (N = 480).

Step	Variable	Zero-order <i>r</i>	B	SE B	$\beta$	$\Delta R^2$
1	Speaker sex	0.28	0.98	0.16	0.28 <sup>†</sup>	0.089 <sup>†</sup>
	Speaker age	-0.10	0.01	0.01	0.01	
	Observer age	0.12	0.01	0.01	0.08	
2	Speaker sex	0.28	1.01	0.16	0.29 <sup>†</sup>	0.026 <sup>†</sup>
	Speaker age	-0.10	0.01	0.01	0.01	
	Observer age	0.12	0.01	0.01	0.09	
	Observer loneliness	-0.15	-0.15	0.04	-0.16 <sup>†</sup>	

Notes.  $R^2 = 0.12$ ; adjusted  $R^2 = 0.11$ ;  $F(4, 461) = 15.10, p < 0.001$ . \* $p < 0.05$ ; <sup>†</sup> $p < 0.001$ . Observer loneliness was grand mean centered.

### 3.2.7 Social Attractiveness

Speakers in the lonely condition ( $M = 6.86, SD = 1.43$ ) were judged as more socially attractive than speakers in the non-lonely condition ( $M = 5.76, SD = 1.82$ ), Welch’s  $t(459.35) = 2.78, p$  (two-tailed) = 0.006,  $d = 0.25$ , so loneliness condition was entered in the first step (no other control variables were relevant). Observers’ loneliness was entered in the second block. VIF scores were  $\leq 1.004$  and tolerance scores were  $\geq 0.99$ . The regression produced a significant overall effect,  $F(2, 463) = 16.32, p < 0.001, \eta^2 = 0.07$ . As predicted, observer loneliness was significantly related to speakers’ perceived social attractiveness,  $\beta = -0.23, p < 0.001$ . H4b is confirmed. Full regression results appear in Table 7.

**Table 7** Multiple Regression Predicting Observers’ Perceptions of Speakers’ Social Attractiveness (N = 480).

Step	Variable	Zero-order <i>r</i>	B	SE B	$\beta$	$\Delta R^2$
1	Loneliness condition	-0.13	-0.39	0.15	-0.12*	0.015*
2	Loneliness condition	-0.13	-0.34	0.15	-0.11*	0.051 <sup>†</sup>
	Observer loneliness	-0.23	-0.19	0.04	-0.23 <sup>†</sup>	

Notes.  $R^2 = 0.07$ ; adjusted  $R^2 = 0.06$ ;  $F(2, 463) = 16.32, p < 0.001$ . \* $p < 0.05$ ; <sup>†</sup> $p < 0.001$ . Observer loneliness was grand mean centered.

### 3.2.8 Task Attractiveness

There were no relevant control variables for task attractiveness, so a bivariate regression was used to test the prediction. The regression produced a significant overall effect,  $F(1, 464) = 30.10, p < 0.001, \eta^2 = 0.06$ . As predicted, observer loneliness was significantly related to speakers’ perceived task attractiveness,  $\beta = -0.25, p < 0.001$ . H4c is confirmed.

## 4. Discussion

At first glance, loneliness appears to be a uniformly aversive experience. Why a tendency to experience loneliness would have evolved in the human species—and why that tendency persists—

have therefore been challenging questions to answer. Cacioppo and Cacioppo's [1] ETL provides that loneliness evolved, in part, to serve a social signaling function, whereby loneliness prompts sensations and behaviors that signal to the self—and, we propose, also to others—that the self is in need of higher quality social connection. This theoretic argument connects loneliness to the need to belong, which Baumeister and Leary [55] argued persuasively is a fundamental human requirement. ETL further claims that, because social connection is so fundamental for human wellness, the experience of loneliness initiates perceptions of vulnerability and hypervigilance to threat. These contentions connect loneliness to well-being and, ultimately, to survival, even though its immediate effects are negatively valenced. In this framework, loneliness operates similarly to negative emotional experiences such as fear [87] and disgust [88] which, although aversive when experienced, function to contribute to an organism's well-being and ultimate survival.

Based on these theoretic arguments, this study tested the social signaling and person perception functions of loneliness by exposing naïve observers to a videotaped self-presentation message from speakers who scored either high or low on a loneliness scale. We hypothesized that, if social signaling is indeed a function of loneliness, as ETL provides, then observers should be able to discriminate lonely from non-lonely individuals at a greater-than-chance level. We further hypothesized that, if loneliness initiates hypervigilance to threat, then this would manifest in a main effect of observers' own loneliness on the beneficence of their perceptions of speakers, such that lonelier observers would evaluate speakers as more lonely, as less attractive, and as having more negative personality attributes.

All of the hypotheses were supported, save for the predicted effect of observers' loneliness on their perceptions of speakers' extraversion. Specifically, speakers in the high-lonely condition were indeed perceived to be lonelier than speakers in the low-lonely condition, which supports the social signaling function of loneliness that ETL implies. For a social signal to function properly, we contend that it must be appreciable by others. In this instance, we demonstrated that observers accurately discriminated lonely from non-lonely speakers, even though observers were given no information about the speakers (save for their instruction to record a personal ad for a new friend) and even though observers were not primed to attend specifically to the speakers' loneliness. Notably, the beta value for the main effect of loneliness condition on observers' perceptions of speaker loneliness was 0.21; given the study  $N$  and the  $SD$  of perceived speaker loneliness, this translates to a Cohen's  $d$  value of 0.43 (95% CI: 0.249 – 0.611; see Lipsey & Wilson [89]), which is close to a medium effect size [90]. We questioned whether observers' own loneliness would interact with speakers' loneliness condition to influence observers' abilities to discriminate lonely and non-lonely speakers, and we found that it did not. On one hand, being lonely oneself might attune one to the signals of loneliness in another (as we speculated). On the other hand, however, loneliness can impair social monitoring ability [53, 54], which would cause loneliness to inhibit the ability to identify loneliness in others. We speculate that these effects may simply have canceled each other out in the present study, resulting in no moderating effect of observers' loneliness.

As hypothesized, observers also had less favorable person perceptions of speakers as a function of the observers' own loneliness. First, net of the effects of speakers' actual loneliness, lonelier observers saw the speakers as lonelier. Lonelier observers also saw speakers as less agreeable, less conscientious, less emotionally stable, less open, and less attractive physically, socially, and from a task perspective. (The effect of observers' loneliness on perceived extraversion was in the hypothesized direction but was shy of statistical significance.) We reasoned that if loneliness



induces hypervigilance to threat, as ETL provides, then this should manifest in less benevolent perceptions of strangers, who may implicitly represent a danger to the self. At least with respect to personality traits and attractiveness (the dimensions of person perception measured here), we found this to be the case.

#### **4.1 Theoretic and Clinical Implications**

A theoretic quandary for social and behavioral scientists has been to explain the existence and persistence of human traits that appear on their surface to be primarily aversive. One approach to doing so is to apply a functional, or adaptationist, perspective, which draws attention to the functions that trait may serve with respect to survival and/or procreation. For instance, the tendency to experience fear—although aversive both physically and psychologically—alerts organisms and conspecifics to the presence of potential threats and motivates corrective action, thereby enhancing the ability to survive those threats [91]. Likewise, depression has been hypothesized to serve an honest signaling function that one's fitness is suboptimal, eliciting assistance from others that contributes to one's viability [92].

Cacioppo and Cacioppo's [1] ETL offers a functional perspective on loneliness by arguing (among other claims) that loneliness contributes to survival both by signaling suboptimal social connection (to elicit repair behaviors) and by increasing vigilance to perceived environmental threats, including threats posed by strangers. The present findings add empirical clarity to these theoretic claims, thereby bolstering ETL's arguments for the functionality of loneliness. As we have argued, a signaling function makes sense only if the signal is socially appreciable, which these findings indicate that it is. We further argued that if loneliness induces a sense of vulnerability and heightened threat, as ETL claims, then this should manifest in more negative person perceptions, particularly with strangers.

ETL's arguments offer guidance not only for understanding loneliness but also for treating it. Although loneliness is not a recognized psychopathology [93], it is a common complaint in psychotherapy [94]. In particular, the hypervigilance to threat induced by loneliness—although it may be functional in the service of viability—may also induce maladaptive social cognitions whereby lonely individuals see potential social connections as more threatening than they are. Such cognitions can have the effect of discouraging potentially beneficial social contacts, motivating social withdrawal and thereby perpetuating the experience of loneliness itself. This would suggest that clinical interventions aimed at correcting maladaptive cognitions (such as by encouraging situation-appropriate vigilance instead of hypervigilance) may be more effective at reducing loneliness than, for instance, interventions aimed solely at increasing opportunities for social contact, and at least one meta-analysis [95] has shown this to be the case. Both cognitive behavioral therapy [96] and interpersonal psychotherapy [97] may be particularly well suited to treating loneliness, due to their focus on correcting maladaptive cognitions (CBT) and supporting meaningful social bonds (IPT).

#### **4.2 Strengths and Limitations**

One strength of the design was the careful selection of speakers from among the highest and lowest quintiles of loneliness scores out of a relatively large potential pool. Although speakers in the lonely condition did not report extreme loneliness (averaging a score of 5.49 on a 9-point scale),

they did evidence substantially higher loneliness than speakers in the non-lonely condition (whose average score on the same scale was 1.74). Indeed, among the full sample of students initially prescreened for loneliness ( $N = 653$ ), only 6.5% reported loneliness scores higher than 5.49.

A second methodological strength was the assignment of ten observers to each video message. Not only did this feature ensure a sample size that offered adequate statistical power, but it mitigated confounds that could be introduced if only one observer had evaluated each video message (see, e.g., Jackson [98]).

A limitation of the present study is the absence of observer personality data. It is possible that observer personality differences resulted in perceiver effects that skewed their perceptions of the speakers (see, e.g., Srivastava et al. [99]). The present study only measured the observers' perceived personality of the speakers, and as such, we cannot conduct the post hoc tests that are necessary to assess the presence or absence of perceiver effects. Future studies utilizing a similar experimental methodological design would benefit from including personality measures for both speakers and observers.

It is also possible that being asked to create a personal ad for a friend may have been awkward for lonely people, insofar as it made their loneliness more salient than it would otherwise have been. As Knowles et al. [100] argued, this may have caused lonely speakers to "choke under pressure." We do not consider this a threat to the validity of the study, however, for two reasons. First, Knowles et al. identified the "choking under pressure" phenomenon only in connection to tasks that were explicitly framed as tests of social aptitude, which the current experimental task was not. Second, a conceptual replication of the Knowles et al. studies, using a substantially larger and more diverse sample, failed to replicate the effect [52].

Some may consider the sample of MTurk workers to be a limitation. Online samples are often critiqued, especially for their representativeness (e.g., Crump et al. [101]; Paolacci & Chandler [102]), and it is certainly the case that an MTurk sample is not truly representative of the U.S. adult population. Specifically, MTurk workers are, on average, younger, underemployed, overeducated, more liberal, and less religious than the general population [80, 81, 103], and MTurk samples tend to overrepresent Asian participants and underrepresent Hispanic and Black/African American participants, relative to the U.S. adult population [80]. These caveats aside, however, we submit that the present sample was likely more diverse in terms of age, socioeconomic status, education, ethnicity, and geography than typical interpersonal communication samples [104]. Indeed, our participants ranged in age from 18 to 74 years, with an average of 42 years of age, and they represented a range of ethnic and racial groups and 44 out of 50 U.S. states plus the District of Columbia. In a comparison of samples recruited from MTurk, from various social media platforms (Twitter, Facebook, Reddit), and from among undergraduate students, Casler et al. [105] found that the MTurk sample was significantly more diverse ethnically and socio-economically than the other samples, bolstering our assertion.

In contrast, the speakers represented relatively restricted diversity in terms of age, race, ethnicity, geography, and education. As predominantly late adolescents, the speakers represented one of the highest-prevalence groups for loneliness in the population [4]. As such, the selection of speakers from this age group was highly appropriate for a study of loneliness, yet because loneliness is affected by age [106] and ethnicity [107], greater diversity among the speakers would be warranted in replications of this study. (The speakers were already balanced by gender, which can also affect loneliness; see Maes et al. [108].)

## 5. Conclusions

Loneliness imposes substantial risks to morbidity and mortality [21], an observation that prompted U.S. surgeon general Vivek Murthy to label loneliness a public health crisis [109]. Nonetheless, loneliness can be adaptive if it is accompanied by appreciable social signaling and if it prompts at least at appropriate level of social vigilance. The present results suggest that loneliness serves both functions. On the basis of these findings, future research might look more descriptively at the attributions that observers make for the loneliness they perceive in others, as their attributions may influence their willingness to offer help (for evidence of this effect in a different context, see Ray et al. [110]). Future studies might also expand the person perception outcomes measured in relation to loneliness to provide a fuller picture of how one's own loneliness influences one's perceptions of others and may even expand that question beyond targets who are strangers (as was the case in the present design).

## Author Contributions

Floyd: study design, analysis, and writing; Woo, Custer, Dinsmore, Duncan, & Maré: data collection, analysis, editing.

## Competing Interests

The authors have declared that no competing interests exist.

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