The Effect of Loneliness on Executive Functioning in Young and Older Adults

By

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Abstract

Loneliness has many risk factors (including being single, a woman, or socially isolated) as well as potentially negative effects on physical, psychological and cognitive health. Baumeister, Twenge, and Nuss (2002) suggested loneliness affects "self regulation" of effort; their notion of 'self-regulation' appears to be similar to "executive function." This dissertation investigated the effect of temporarily induced loneliness on young and older adults' executive functioning, a critical ability for maintaining independence of older adults. The experimental design was a near replication of the Baumeister, Twenge, and Nuss (2002) experiment which primed loneliness in young adults by providing false feedback indicating a future of being alone. This dissertation extended their approach to older adults and examined whether loneliness priming impairs cognitive and executive functions, as measured by reading comprehension, the Stroop test, and the Trail Making task. Unexpectedly, over 40% of the participants were classified as lonely based on the de Jong Gierveld Loneliness Scale with similar patterns of loneliness across both age groups. Non-lonely participants, regardless of age, who were presented with the future alone prime manipulation did not show the hypothesized effects of reduced cognitive function, on reading comprehension or executive function, failing to replicate the findings of Baumeister, et al. These findings are discussed in respect to their implications for theories of loneliness and executive function.

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Chapter 1: Loneliness

Loneliness is a common human experience. Older adults, women, and those who are socially isolated may be at increased risk for loneliness. Loneliness has negative consequences for emotional well-being and physical health. Most importantly, loneliness has been linked to age-related cognitive declines. The nature of loneliness has been described as both a trait, or enduring dispositional loneliness, and a state, or transient loneliness. State loneliness has been linked to cognitive declines and has been assessed using surveys. The two major loneliness scales, UCLA Loneliness Scale and the de Jong Gierveld Loneliness Scale, are commonly used. This review will summarize current models of loneliness including risk factors for the development of state loneliness and its association with aging as well as its impact on older adults' health and cognitive function. Experimentally inducing state loneliness with a priming technique will be evaluated for assessing the effect of loneliness on older adults' cognitive function.

Definition of Loneliness

The dominant view of loneliness is that perceived deficits in the number or types of social relationships give rise to a sense of loneliness. Weiss (1973) proposed two components of loneliness: emotional isolation and social isolation. Emotional isolation occurs when people believe they lack a close confidante or partner, i.e., spouse. Emotional isolation commonly occurs following the dissolution of a marriage or close relationship through separation, divorce, or death, but can dissipate with the development of a new confidant (de Jong Gierveld, Van Tilburg, & Dykstra, 2006). On the other hand, social isolation occurs when people believe that they do not have their desired or appropriate relationships. Social isolation may be caused by limited or no access to friends or family. Additionally, people who believe they have the "wrong types" of relationships in their lives experience social isolation (Weiss, 1973). Both components of loneliness are driven by people's individual social comparisons and expectations; two people with similar relationships can assess their lives differently so that one may feel lonely and the other not (de Jong Gierveld et al., 2006).

Cacioppo and Hawkley (2009) expanded the definition of loneliness to include a third component: negative perceptions of relationships. These negative interpretations are "unpleasant and

distressing" and can occur regardless of the person's relationships. Consistent with these views, Rokach (2012) suggests loneliness is not driven by the number of friends or the amount of contact a person has with others, but instead caused by the subjective perception of the situation. This suggests it is possible to experience isolation without experiencing negative feelings such that isolation does not cause loneliness.

Research on Loneliness

Prevalence. Loneliness impacts people regardless of age, gender, marital status, education and ethnicity. People as young as 3 years of age can report feelings of loneliness (West, Kellner, & Moore-West, 1986). In a large scale survey, Rubenstein, Shaver, and Peplau (1979) found 94% of respondents aged 18 to 80 report experiencing feelings of loneliness at some time in their lives. Other studies report various rates of loneliness ranging from 10% up to 40% of respondents (Hawkley & Cacioppo, 2010; Hawthorne, 2008; O'Laughlin et al., 2012; Weeks, 1994). Conflicting estimates may arise from sampling approaches that focus on different correlates of loneliness. In their review, Routasalo and Pitkala (2003) identified gender, marital status, living situation, childlessness, widowhood, social networks, mental state, and physical health as correlates of loneliness. The relatively stable number of people who report being lonely, regardless of which correlates are assessed, may arise from the fluctuating transient experiences of loneliness within the population.

Risk factors for loneliness. Loneliness has traditionally been considered a problem of old age (Victor, Scambler, Bond, & Bowling, 2000). As early as 1978, Wood reports declining rates of loneliness from 18 to 54 years. Contrary to those findings and popular belief, Hawthorne reports (2008) that younger adults have the highest prevalence of loneliness, with 10% of participants between 15-30 years reporting serious isolation and loneliness. Likewise, Russell (1996) reports that average loneliness scores on the UCLA Loneliness Scale were significantly higher in college age participants (M = 40.1 of 80 points) than for older adults over 65 years (M = 31.5). In a meta-analysis, Pinquart and Sorensen (2001) report declining rates of loneliness with age for a subgroup of adults with a mean age of less than 60 years, no significant relationship between loneliness and age for older adults between 60 to 80 years, and increasing rates of loneliness with age for adults over 80 years. This U-shaped pattern for rates of loneliness may be

driven by the changing social roles that older adults navigate as a result of retirement, illness, death of friends and family, and changing residences.

Although loneliness may be as prevalent or more prevalent among young adults as among older adults, research has identified a number of factors affecting loneliness within the older population. Victor, Scambler, Bond, and Bowling (2000) reported the median rate of older adults over 65 years who are "very lonely" is 10% across large sample community studies. Increased loneliness is observed most dramatically in the oldest old segment of the population. In a study of rural adults, Dugan and Kivett (1994) found that 60% of the oldest old (M = 83 years old) report some degree of loneliness and an additional 20% report often feeling lonely. The oldest old adults are likely to experience an accumulation of risk factors that contribute to loneliness (Cornwell, Laumann, & Schumm, 2008), which may include loss of spouse, diminishing social networks, and poor health. Each of these risk factors can independently contribute to loneliness but are often compounded in older adults.

Gender is believed to be a risk factor for loneliness. Women have been classically perceived as having a higher risk of being lonely than men. To support this, Borys and Perlman (1985) state women self-report more loneliness than men. Gender differences regarding expectations and interpretations about social relationships may affect how men and women assess their loneliness (Van Baarsen, Snijders, Smit, & Van Duijn, 2001). Cacioppo and Hawkley (2009) suggest women may have higher expectations for social support such that relationship losses increase their risk for social isolation. Cacioppo and Hawkley (2009) also suggest women are at greater risk of loneliness because of gender differences in life expectancy. Women live longer than men, increasing their risk of losing their partners and living alone, hence increasing their risk for emotional isolation. Although there is conflict about how gender differences influence risk of loneliness, it is clear that gender plays a role in loneliness.

A number of other factors have been linked to loneliness including marital status (Pinquart, 2003), social isolation (Victor et al., 2000), and social network size (Van Tilburg, 1990). The presence of a spouse reduces emotional loneliness (Green, Richardson, Lago, & Schatten-Jones, 2001; Liebler & Sandefur, (2002) and Pinquart (2003) report married adults are less likely to report being lonely than

divorced, widowed, or never married adults. While all unpartnered adults are more likely to report being lonely, divorced and never married men are more likely to report higher rates of loneliness than divorced or never married women (Pinquart, 2003). Therefore, it seems that social connection with a spouse or an emotional confidante reduces loneliness.

Isolation is a risk factor for loneliness. Victor et al. (2000) report 68% of individuals living alone are classified as socially isolated compared to 3% of individuals in other living situations. Because living alone reduces social contacts, individuals who live alone may experience more social isolation, a component of Weiss' model of loneliness (1973). Van Tilburg (1990) states that the 4 closest relationships within a social network are the most protective against loneliness, whereas those with fewer than 4 close relationships report increased loneliness and having more than 4 close relationships results in only a marginal decrease in loneliness. Shankar, Hamer, McMunn, and Steptoe (2013) also reported a significant positive relationship between social isolation and loneliness (B (SE) = 0.02 (0.002), $p < 0.01$, $\beta = .18$). Being isolated does not guarantee that an individual will experience loneliness. Rather, individuals experience a sense of loneliness when the amount of contact they need or desire does not match the contact they receive (Rokach, 2012).

Loneliness is correlated with a number of risk factors, including old age, being female, and being unmarried or never married. However, Hawkley, Hughes, Waite, Masi, Thisted, and Cacioppo, (2008) argue that social expectations and comparisons, rather than the number of risk factors or the degree of social isolation per se, contribute to the subjective experience of loneliness.

Consequences of Loneliness

For emotional and physical health. Loneliness has been tied to a number of negative emotional and health outcomes including reduced subjective well-being (VanderWeele, Hawkley, & Cacioppo, 2012), depression (Alpass & Neville, 2003), smoking (Shankar, McMunn, Banks, & Steptoe, 2011), sedentary lifestyle (Shankar et al., 2011), sleep problems (de Jong Gierveld, 1998), increased health problems (Hawkley et al., 2008), and increased mortality risk (Holt-Lunstad, Smith, & Layton, 2010). Vanderweele, Hawkley, and Cacioppo (2012), using data from the Chicago Health, Aging, and Social

Relations Study, reported that loneliness and subjective well-being were significantly associated. As people become lonelier, their subjective well-being declines. Alpass and Neville (2003) report that loneliness is significantly correlated with depression (r = .625) in older men. Shankar, McMunn, Banks, and Steptoe (2011) report that lonely individuals have a 10% increase in the odds of being a smoker compared to less lonely individuals and a 13% increase in the odds of being inactive compared to less lonely individuals. Cacioppo et al. (2002) report that lonely individuals had significantly lower sleep efficiency, the percentage of time spent in bed actually sleeping, than non-lonely individuals (83% and 90%, respectively). Lonely individuals have more chronic health issues and restrictions on their daily activities than non-lonely individuals (Hawthorne, 2008). In a meta-analysis of mortality risk, Holt-Lunstad et al. (2010) report a 50% increase in survival odds when people have social relationships and a 91% increase in survival odds when people are socially integrated. These increases in mortality risk match or exceed many of the well-known risk factors for mortality such as alcoholism, obesity, and smoking (Holt-Lunstad et al., 2010).

For cognitive function. Loneliness has been linked to poor cognitive function, often in conjunction with measures of social support. People who lack social support are at a greater risk for becoming isolated (Weiss, 1973). In a 7.5 year longitudinal study, Seeman, Lusignolo, Albert, and Berkman (2001) report that people who had better social support at baseline also had better cognition function at baseline. Further, after 7.5 years, those individuals with limited social support at baseline experienced more cognitive decline (Seeman et al., 2001) relative to those with better initial social support. While the overall variance in cognitive decline explained by social support (1%) was low, the accumulated impact of social support on cognitive function over lifespan may be considerable. This suggests having social support protects against social isolation and may reduce the amount of cognitive decline over the lifespan.

Individuals with more emotional support experience reduced cognitive decline according to data from the Baltimore Epidemiologic Catchment Area Longitudinal Study (Holtzman et al., 2004). Holtzman et al. suggest that people with social networks that provide emotional support have increased

social and cognitive stimulation that protects against cognitive decline. Contrary to Holtzman et al., Green, Rebok, and Lyketsos (2008) report that those individuals with higher initial emotional support experienced greater cognitive decline than those with more limited initial social support; they also used the Baltimore Epidemiologic Catchment Area Longitudinal study. This contrary finding may indicate that cognitive declines may be accelerated when people experience losses or reductions in social network size over time because individuals who have more initial support have more to lose. Additionally, Green et al. conclude that the contradictions with Holtzman et al. (2004) come from the different participant subsets. Green et al. required older adults to be involved with the study for 20 years whereas Holtzman et al. included used only study participants with data from both Wave 1 and Wave 3 of the longitudinal study (averaging 12.4 years time lapse). The longer time frame used by Green et al. (2008) may allow a shift in the pattern of social support and dementia to be evident. Fratiglioni, Paillard-Borg, and Winblad (2004) report that in a collection of the six observational longitudinal studies of social networks and dementia, three studies suggest that dementia risk is increased when people are single, widowed, or living alone, all risk factors for loneliness. The remaining studies suggested that dementia risk was reduced by mental and physical engagement in activities (i.e. leisure activities, knitting, travel) which may be enhanced by the social support that such activities provide.

Some studies demonstrate a direct link between loneliness and cognitive function. Conroy, Golden, Jeffares, O'Neill, and McGee (2010) report that lonely individuals, as assessed by a single item ("How often in the past 12 months have you been bothered by loneliness?"), have a higher risk for low scores on cognitive assessments ($OR = 1.7$, $p = 0.033$) and possible cognitive impairment ($OR = 3.0$, $p = <0.001$) than non-lonely individuals. They also found that lonely individuals had an increased risk of dementia ($OR = 2.7$, $p = 0.001$), when loneliness was considered along with other measures of social engagement, proneness to boredom, and being never married. Loneliness increasing the risk of developing dementia was also reported by Holwerda et al. (2012) from the Amsterdam Study of the Elderly data ($OR = 1.64$, $CI = [1.05,2.56]$). They specifically stated that the feelings of loneliness and not the actual experience of being alone was the more critical predictor of dementia onset. Gow, Pattie,

Whiteman, Whalley, and Deary (2007) report that there is an association between loneliness, as assessed by two questions ("On a five point scale, rate whether or not you feel lonely at the present time" and "Do you have people to talk to when you have problems"), and cognitive ability (r = -.22, p = .000) in older adult women, but not for older men (r = -.09, *ns*). They also report loneliness remained a significant predictor of cognitive function at age 79 even after adjusting for IQ at age 11, sex, education, and SES. This suggests that change in cognitive functioning is related to change in the experience of loneliness..

Other recent longitudinal studies continue to provide strong support for the theory that loneliness has detrimental effects on cognition. O'Luanaigh et al. (2012) used the Dublin Healthy Ageing Study to assess the effect of loneliness on both global (MMSE) and specific cognitive domains, such as visual memory, processing speed, working memory in older adults (M = 75.5 years, SD = 6.1). Higher levels of loneliness were found to be significantly associated with lower MMSE scores (t = 5.35, p < 0.01, *CI* [0.04, 0.09]), when other variables such as depression and social networks were controlled for. Additionally, higher levels of loneliness were also associated with reduced visual memory and processing speed. Shankar, Hamer, McMunn and Steptoe (2013) reported similar findings from the English Longitudinal Study of Ageing. They found that greater cognitive decline was associated with both loneliness and social isolation. Loneliness was again associated with poorer recall, particularly lonely individuals who were more isolated. Shankar et al. also reported that the effects were more pronounced in individuals with lower education. These recent studies bolster the connection between loneliness and cognition that was implied by studies of social isolation and social support.

Measuring Loneliness

Trait loneliness and state loneliness. Loneliness has been considered as both a persistent trait and as a temporary state. Trait loneliness is a chronic, dispositional attribute that develops at a young age (Dill & Anderson, 1999). Van Baarsen et al. (2001) reported that trait loneliness is related to other aspects of personality such as shyness and impaired social interaction. State loneliness is a temporary experience that is induced by an individual's negative perceptions or interpretations of the situation (Hector-Taylor & Adams, 1996). Because surveys of the prevalence of loneliness focus on the individual's current

experience (Cacioppo, Hawkley, & Thisted, 2010; Rubenstein et al., 1979), state loneliness is more commonly assessed than trait loneliness. Hector-Taylor and Adams (1996) report trait and state loneliness are highly correlated (r = 0.86). However they had participants complete the UCLA Loneliness Scale twice while considering their feelings over the two time periods, either over the last two weeks or over the course of the individual's life, which may have resulted in a spurious correlation. Hector-Taylor and Adams (1996) note that state loneliness has higher predictive variance for all health variables than trait loneliness such that older adults may experience more negative consequences from short-term state loneliness than from long-term trait loneliness.

Loneliness scales. In a meta-analysis, Pinquart and Sorensen (2001) report that the dominant assessment instruments used to measure loneliness are the UCLA Loneliness Scale (Russell, Peplau, & Ferguson, 1978; Russell, Peplau, & Cutrona, 1980) and the de Jong Gierveld Loneliness Scale (de Jong Gierveld, 1987). State and trait loneliness can both be measured using the same scales. The only difference is in administration of the measure and whether participants are asked to report feelings of loneliness over a short time frame, e.g., 2 weeks, or a longer time frame, e.g., their lifetime.

The UCLA Loneliness Scale was originally developed to provide a standardized measure of loneliness that was both short and reliable (Russell et al., 1978). The UCLA Loneliness Scale has excellent reliability (α = .92 and α = .89 for college students and older adults, respectively). The de Jong Gierveld Loneliness Scale was constructed with two subscales based on Weiss' definition (1973) of loneliness using emotional isolation and social isolation. Both the overall reliability (α = .84) and that of the individual subscales (emotional isolation and social isolation, α = .88 and α = .88, respectively) on the de Jong Gierveld Loneliness Scale are excellent (de Jong Gierveld & Van Tilburg, 2006).

The UCLA Loneliness Scale and the de Jong Gierveld Loneliness Scales share a number of characteristics. Both use positively and negatively worded items including "How often do you feel part of the group?" and "How often do you feel that you lack companionship?" from the UCLA Loneliness Scale; "There are many people I can trust completely" and "I miss having people around" from the de Jong Gierveld Loneliness Scale. Responses are based on a continuum of loneliness (i.e. "I often feel this

way; I sometimes feel this way; I rarely feel this way; I never feel this way" from the UCLA Loneliness Scale; "yes," "more or less," and "no" from the de Jong Gierveld Scale). Both scales specifically avoid the words "loneliness" and "lonely" in the wording of the items to limit the potential effect of social desirability and stigma (de Jong Gierveld, 1998). Gender differences on these scales suggest that men respond more extremely to negatively worded items and women respond more extremely to positively worded items (Hawkley et al., 2008; Van Baarsen et al., 2001).

Using the Revised UCLA Loneliness Scale, Alpass and Neville (2003) studied the relationships between loneliness, health and depression in older adult males. Among older men, the UCLA Loneliness Scale was significantly correlated with marital status (r = -.364, p < .01), living alone (r = .287, p < .01), network size (r = -.300, p < .01), self-rated health (r = -.300, p < .01), and depression (r = .625, p < .01). New findings from Cacioppo, Hawkley, and Thisted (2010) report that the UCLA Loneliness Scale had temporal stability across a 5-year longitudinal study (β = 0.79, 95% CI [0.66, 0.92]) in a sample of 229 adults, ages 50 to 68. This 5-year time period does not fit neatly within the framework for either state or trait loneliness. It would be considered too long for a classic study of state loneliness and too short for a study of trait loneliness. However, 5 years in this age group may be optimal for assessing stability versus change in loneliness as critical age-related life course changes in family, work, and friendship occur during this interval, possibility contributing to loneliness.

Pinquart and Sorenson (2001) report a high internal consistency (α = .88) in the de Jong Gierveld Loneliness Scale from a sample of 4130 older adults, ages 53 to 79 years. Van Baarsen et al. (2001) report, in a large sample of older adults (N = 4,494) age 55 to 89 years, reliabilities for the overall de Jong Gierveld Loneliness Scale, emotional isolation subscale and the social emotional subscale (α = .82, α = .81 and α = .73, respectively) with a significant correlation (r = .55) between the two subscales. De Jong Gierveld, Broese van Groenou, Hoogendoorn, and Smit (2009) again report reliabilities on the emotional isolation and social isolation subscales, α = .80 and α = .73, respectively, in older adults, ages 64 to 92.

The two major loneliness scales, the de Jong Gierveld Loneliness Scale and the UCLA Loneliness Scale have been validated for use in young and older adult populations. Although the two

scales share a number of characteristics, the de Jong Gierveld Loneliness Scale was constructed based on Weiss' definition of loneliness (1973) which continues to guide the work on loneliness making it the more appropriate choice for the current research. In addition, scoring cutoffs have been developed for the composite scores to assess loneliness severity (Van Tilburg & de Jong Gierveld, 1999).

Experimentally Inducing Loneliness

Loneliness can be induced using a priming technique. Twenge, Baumeister, Tice, and Stucke, (2001) induced feelings of social isolation by providing false information about an individual's personality profile to create a temporary experience of loneliness. In this procedure, the participant first completes a short extraversion checklist; then, the participant is given false feedback about their "personality type" based on a randomly assigned feedback condition (positive, negative or neutral). In the positive feedback condition, "future belonging" is emphasized; the person is told he or she will have good relationships throughout their lives. In the negative feedback condition, a "future alone" is described; the person is told she or will have poor relationships throughout their lives and end up alone. In the neutral feedback condition, "future misfortune" is forecast; the person told he or she will be accident-prone throughout their life without any mention of social relationships. Twenge et al. found that participants who experienced induced loneliness were more likely to engage in negative behaviors such as giving hostile evaluations or directing higher volumes of noise to targets believed to have insulted them than participants who had not been given a "future alone" prime.

Baumeister, Twenge, and Nuss (2002) extended this approach to examine the effect of priming loneliness on cognition and self-regulation. The primary finding from the first experiment was that participants randomly assigned to the "future alone" condition had significantly lower scores on a multiple choice intelligence test than individuals in either the "future misfortune" or the "future belonging" conditions (future alone, M = 18.92 items correct, SD = 7.39; future misfortune, M = 24.77, SD = 4.49; future belonging, M = 25.79, SD = 5.10). Baumeister et al. reasoned if the drop in scores was simply a function of bad news, participants in both the "future misfortune" and "future alone" conditions would have statistically lower scores than the "future belonging" participants. In a manipulation check,

Baumeister et al. found that "future alone" participants were significantly more skeptical of the priming than "future belonging" participants; however, "future alone" participants still showed negative effects of the prime.

In another experiment, Baumeister, Twenge, and Nuss (2002) assessed the impact of loneliness on another aspect of cognition, memory. Participants were either assigned to a "encoding affected" condition or a "recall affected" condition. In the encoding affected condition, the loneliness prime was presented before participants read the passages; they were then debriefed, and then tested on reading comprehension. In the recall affected condition, participants were given passages to read; then provided with the loneliness prime; then tested on reading comprehension; then debriefed. Although Baumeister et al. (2002) states the task is recall, the questions were taken from standardized tests of reading comprehension. Two types of passages were contrasted: a hard passage which was "long and difficult" and an easy passage which was "short and comparatively easy." In the encoding affected condition, when the deception or false feedback was revealed during a debriefing session before the comprehension task, no effect of priming condition on passage comprehension was detected regardless of the passage difficultly (Easy Passage: future alone, $M = 3.78$, $SD = 1.20$; future misfortune, $M = 4.70$, $SD = 0.48$; future belonging, $M = 3.50$, $SD = 1.43$; Difficult Passage: future alone, $M = 4.78$, $SD = 1.20$; future misfortune, $M = 4.60$, $SD = 2.17$; future belonging, $M = 4.40$, $SD = 2.01$). This suggests that individuals in the encoding affected condition did not experience any cognitive disruption due to the loneliness prime.

In the recall affected condition, when the deception was not revealed until after the comprehension task, priming condition did affect passage comprehension, but only for the difficult passages. For easy passages, there was no significant difference in comprehension (future alone, $M = 4.25$ correctly recalled, $SD = 1.42$; future misfortune, $M = 4.67$, $SD = 0.89$; future belonging, $M = 3.83$, $SD = 1.11$). For difficult passages, there was a significant effect of condition where participants in the future alone condition correctly recalled fewer answers than the other conditions (future alone, $M = 2.75$ correctly recalled, $SD = 1.60$; future misfortune, $M = 4.58$, $SD = 2.02$; future belonging, $M = 4.75$, $SD =$

1.54). Baumeister, Twenge, and Nuss (2002) conclude that primed loneliness impairs cognitive function on difficult tasks that require executive control.

According to Baumeister, DeWall, Ciarocco, and Twenge (2005), priming loneliness decreases self-regulation. Baumeister et al. (2005) define self-regulation as "an effective capacity for altering … behavior so as to conform to externally (socially) defined standards" (p. 589). Participants who were primed with a "future alone" drank less of a "healthy" beverage, ate more cookies, and were less persistent on difficult puzzles compared to "future misfortune" or "future belonging" participants. However, Baumeister et al. also found that the reduced self-regulation in "future alone" participants was based on an unwillingness to make an effort rather than an inability to do so. When given significant incentive (money) for their performance, "future alone" participants performed as well as participants in the other conditions, suggesting they were capable of self-regulation. Baumeister et al.'s (2005) definition of self-regulation mirrors the cognitive psychological understanding of executive function, suggesting that priming loneliness can result in short-term changes to executive function.

If priming loneliness can induce short term changes to executive function, naturalistic occurrences of loneliness are potentially far more potent determines of poor cognitive function. It is particularly intriguing to speculate that many age-related cognitive declines in executive function may arise from age-related increases in loneliness.

Chapter 2: Executive Functioning and Loneliness

Executive function is studied in both the social psychology and cognitive psychology; however, the two fields approach the concept differently. Social psychological research approaches executive function as an individual's ability to act with agency on one's own behalf (Baumeister, Bratslavsky, Muraven, & Tice, 1998). They suggest self-regulation is a finite resource, it can be exercised like a muscle, it requires energy/vitality, and it can be exhausted (Baumeister, et al., 1998; Muraven, Baumeister, & Tice, 1999; Baumeister, Muraven, & Tice, 2000). When an individual's capacity for self-regulation has been reduced, s/he may experience "ego depletion." Ego depletion is the "temporary reduction in the self's capacity or willingness to engage in volitional action (including controlling the environment, controlling the self, making choices, and initiating action) caused by prior exercise of volition" (Baumeister, et al., 1998, p. 1253). These conceptual understandings of executive function, self-regulation, and ego-depletion have been tested using behavioral tasks.

In a recent social psychological study by Shelton et al. (2011), older adults exposed to either a difficult Stroop test or an easy Stroop test performed differently on a subsequent memory task. Older adults who completed the easy Stroop test performed better on the memory task then those who completed the difficult Stroop test. The results were interpreted as demanding tasks cause greater ego depletion, reducing control over attentional processes. Shelton et al. also reported an age effect; the oldest old were more susceptible to the resource depletion than the young-old. If the Shelton et al. (2011) study were reinterpreted from a cognitive perspective, the cognitive psychologist would conclude that manipulating the difficulty of the Stroop test differentially taxed executive function. The more difficult Stroop test demanded more executive control, particularly inhibition of competing responses, reducing attentional control on the memory task. It is not surprising that older adults were more susceptible to this manipulation since age-related declines in executive function are well-established. The patterns and descriptions of "self-regulation" and "ego depletion" in social psychology appear to be similar to the constructs of "executive function" and "loss of inhibition" studied within cognitive psychology.

Recognizing the connections between the cognitive and social psychological vocabulary is relevant to building cognitive research questions that may benefit from the social psychological method. From a cognitive perspective, Miyake and colleagues (2000) define executive function as the "general purpose control mechanisms that modulate the operation of various cognitive sub-processes and thereby regulate the dynamics of human cognition" (p. 50). Executive functions have also been defined as "those capacities that enable a person to engage successfully in independent, purposive, self-serving behavior" (Lezak, Howieson, & Loring, 2004, p. 35). Other definitions include "a multidimensional construct referring to a variety of loosely related higher-order cognitive processes including initiation, planning, hypothesis generation, cognitive flexibility, decision-making, regulation, judgment, feedback utilization, and self perception" (Spreen & Strauss, 1998, p. 171), and a bundle of "general purpose control mechanisms that modulate the operation of various cognitive subprocesses" (Miyake et al., 2000, p. 50). Baumeister et al.'s notion of "self-regulation" would seem to a candidate for inclusion within the broader construct of "executive function."

Measuring Executive Function

Although no definitive test for executive function has been established (Rabbitt, 1997), there are widely accepted tests for specific executive functions. Of these, the most widely studied executive function tests are the Stroop Test (Stroop, 1935) and the Trail Making test (Reitan, 1955; Reitan & Wolfson, 1993; Arbuthnott & Frank, 2000; Sanchez-Cubillo, et al., 2009)

Both the Stroop Test and the Trail Making Test involve 2 parts: in the first part participants are timed as they perform a simple perceptual-motor task (e.g., naming colors or connecting dots in numerical order). In the second part, participants perform a similar task but this time they must ignore irrelevant information (color words presented in a contrasting ink color) or rapidly alternate tasks (switching between letters and numbers). An inference score is computed, reflecting the additional time required to perform the second task compared to the first. These tasks are widely researched and are supported by decades of psychological testing.

On tests like the Stroop and Trail Making Tests, young adults tend to have lower interference scores than older adults (Arbuckle & Gold, 1993, McDowd, et al., 2011; Friedman & Miyake, 2004; Salthouse, Atkinson, & Berish, 2003). Healthy adults have lower interference scores than adults with neurodegenerative disorders such as Parkinson's disease (Arbuthnott & Frank, 2000; McDowd, et al., 2011; Muslimovi , Post, Speelman, & Schmand, 2005) or Alzheimer's disease (Bélanger, Belleville, & Gauthier, 2010; McDowd, et al., 2011). Thus, predictable patterns of results can be hypothesized when working with different clinical populations and age groups.

Inhibitory Deficit Theory

Hasher and Zacks (1988) developed the Inhibition Deficit Theory (IDT) as a framework for explaining general age-associated cognitive declines. IDT suggests age-related declines in inhibition account for many of the cognitive deficits experienced by older adults (Hasher, Zacks, & May, 1999; Hasher, Zacks, & Rahhal, 1999; May, Zacks, Hasher, & Multhaup, 1999; Zacks & Hasher, 1994). The theory focuses on the underlying functions of inhibition and its impact on working memory through access, deletion, and restraint (Hasher, Zacks, & May, 1999). Inhibitory processes determine what information enters working memory (access), what is purged from working memory as irrelevant (deletion), and what information can be bypassed before even entering working memory (restraint). Inefficient inhibitory control can lead to difficulty filtering environmental stimuli, thereby filling working memory with irrelevant information (Hasher, Stoltzfus, Zacks, & Rypma, 1991). Slower reading or processing speeds, slower reaction times, and memory failures in both recognition and recall of relevant information are all indications of reduced inhibition.

Loneliness and Executive Function

Loneliness may contribute to both short-term and long-term cognitive declines by contributing to a loss of inhibition. Hasher and Zacks (1988) suggest that "personalistic memories or concerns" (p. 213) intrude into working memory as a result of a breakdown of inhibition. They maintain that "the increased presence of irrelevant thoughts in working memory (and the attendant consequences) may well be the factors that preclude the behaviors that have made it appear as if older adults have reduced capacity for

cognitive functions" (p. 216). They continue "the failure… to inhibit non-goal-path thoughts comes from observations of … tendencies to infuse conversations with personalistic intrusions" (p. 216). Feeling lonely may have a similar effect on cognition by shifting attention away from task-relevant thoughts to thoughts about emotional and social isolation. If so, lonely individuals may experience a breakdown of executive function on tests like the Stroop and Trail Making Tests. And priming loneliness may also induce short-term loss of executive function, with a resulting increase in Stroop and Trail Making interference scores, in both young and older adults.

Hypotheses

This dissertation sought to examine the relationship between loneliness, age, and executive function.

1) Does loneliness priming cause immediate cognitive change in both young and older adults?

Though cognitive changes could refer to any number of cognitive or executive functions, the current project specifically focused on reading comprehension and two specific executive function tests, Trail Making and Stroop. Baumeister et al., (2002; 2005) showed that induced loneliness resulted in short-term changes to young adults' reading comprehension; however, their priming technique was never tested using an older adult sample. The research attempted to replicate the Baumeister et al. (2002) study, adding an older adult sample.

Older adults were theorized to be as susceptible to loneliness priming as young adults. That is, both young and older adults in response to the future alone priming manipulation were hypothesized to experience a temporary increase in the experience of loneliness, resulting in a decrease in self-regulation, which, in turn, resulted in short-term cognitive decline. Baumeister et al. (2002) tested this hypothesis by comparing the effects of the "future alone" priming manipulation to those of a "future belonging" and "future misfortune" primes on reading comprehension. This dissertation extended this hypothesis to examine the effects of these three priming conditions on young adults, ages 18 to 22, and older adults, ages 62 to 96.

2) Does the loneliness priming affect reading comprehension, executive function, and self-perception of cognitive age?

The effect of loneliness priming on one test of cognitive function, reading comprehension, and two executive function tests, Trail Making and Stroop, was investigated. Reading comprehension was assessed by having participants read and answer questions about SAT passages; the two commonly used measures of executive function, Trail Making and Stroop, were assessed to directly determine the affect of loneliness priming. Executive function has been shown to be susceptible to age-related breakdown. Both executive function tests have been shown to be highly sensitive to other manipulations (May, Hasher, & Foong, 200) and less susceptible to both floor and ceiling effects, which may limit interpretation of the reading comprehension measures. Hence, assessing whether loneliness priming affected executive function could help clarify the mechanisms underlying the priming effects observed by Baumeister et al. (2002) and also clarify how loneliness may contribute to age-related declines in other cognitive functions.

In addition, participants were asked about their self-perception of their cognitive age (Edwards, 1994); the future alone prime was expected to suppress participants' sense of their own competency, reducing their cognitive age, e.g. participants should report feeling older than their actual chronological age. whereas the belonging and misfortune primes were not expected to affect participants' sense of their own cognitive competency, e.g., participants should report feeling the same or younger than their actual chronological age.

Chapter 3: Method

Research Design

The experiment was a near replication of Baumeister, Twenge, and Nuss's (2002) second experiment. The current experiment made three major changes to the original study: an older adult sample was included, the *recall affected* procedure was selected, and classic tests of executive function were added. In addition to assessing the effect of primed loneliness on reading comprehension, its effects on executive function were also assessed to provide more insight into how state loneliness may contribute to older adults' cognitive declines. The experimental design was 2 (age groups) x 3 (priming conditions) with 3 outcome measures: reading comprehension, Stroop interference, and Trail Making interference.

Power analysis. Baumeister, Twenge, and Nuss (2002) reported $d = 1.01$ to detect differences between Future Alone ($M = 2.75$, $SD = 1.60$) and Misfortune ($M = 4.58$, $SD = 2.02$) priming conditions on difficult passage questions. This was a large effect in a young adult sample. In Baumeister et al. (2002) the easy passage used 5 questions while the difficult passage used 7 questions. In the current research, each passage had 7 questions to improve power. Using G-power (Erdfelder, Faul, & Buchner, 1996) with the effect size of 1.01 and a power of 0.85, this study required 19 participants per condition, or 114 participants (57 young adults and 57 older adults) to detect differences. See Table 1 for the distributions of the 196 participants within conditions. Even though data collection exceeded the proposed sample, the number of participants identified as lonely limited the number of participants that were available for the priming manipulation. A power analysis was conducted for each age group to assess the actual power between the three conditions for reading comprehension. For the young adults, with the reading comprehension totals for future alone ($N = 17$; $M = 7.24$), future belonging ($N = 18$; $M = 5.67$), and future misfortune ($N = 18$; $M = 6.28$), the calculated effect size was 0.76. For the older adults, with the reading comprehension totals for future alone ($N = 19$; $M = 7.26$), future belonging ($N = 20$; $M = 6.95$), and future misfortune ($N = 20$; $M = 8.85$), the calculated effect size was 0.99. The effect sizes indicate sufficient power to detect small effects due to the priming manipulation.

Table 1.

Summary of random assignment to conditions.

	Young Adults	Older Adults
Non-Lonely: Primed		
Alone	17	19
Belonging	18	20
Misfortune	18	20
Non-Lonely Sub-Total	53 (57%)	59 (58%)
Lonely: Not Primed	40 (43%)	42 (42%)
Total	93	101

Participants. The 93 young adults (18 - 30 years old, *M* = 19.11, *SD* = .92) were recruited from the Introductory Psychology classes of a large public university. Students were tested in an on-campus lab and received research credit for their participation. The 103 older adults (62 - 96 years old, *M* = 72.05, *SD* = 7.22) were recruited through a database of former research participants, community outreach, newspaper advertisements, and a targeted emailing to university alumni through the Alumni Association. They received an honorarium for their participation. Older adult testing was conducted at independent living retirement communities or university research space. Two older adults were dropped from the final analysis because they were unable to complete the cognitive tasks in the battery.

Procedure

Test administration. A summary of the tests and procedures from the experiment is provided in Appendix A and summarized below. Tasks 5, 6, 9, 12, and 13 were administered using E-prime (Schneider, Eschman, & Zuccolotto, 2002).

1. Informed Consent
2. Random Assignment to Prime Condition
3. Demographic Information
4. De Jong Gierveld Loneliness Scale
5. Ten Item Personality Inventory
6. Shipley Vocabulary Test

7. Executive Function Measures (Part 1)
8. Reading Span
9. Reading Passages
10. Personality and Priming Feedback
11. Executive Function Measures (Part 2)
12. Reading Comprehension
13. Cognitive Age
14. Probe Questions and Debriefing

Informed Consent. Each participant listened to the oral pre-consent script highlighting the data that would be collected, the anonymity of their answers, and their option to discontinue at any time before they read the paper consent form. Following the pre-consent script, all participants were provided written informed consent. This information was repeated in the written consent form. The consent script and informed consent forms are included in Appendix B.

Random Assignment to Prime Conditions. Participants were randomly assigned to one of three conditions for the loneliness priming manipulation: the future alone condition, the future belonging condition, or the future misfortune condition (see Personality and Priming Feedback, p. 36).

Exclusionary Criteria. All participants completed the de Jong Gierveld Loneliness Scale (see Table 4). Participants' answers were immediately scored to determine their current loneliness state. Scores equal to or greater than 3 have been used by van Tilburg and de Jong Gierveld (1999) to distinguish lonely individuals from non-lonely individuals. Participants with scores equal to or greater than 3 on the scale were considered to be lonely and were excluded from the priming manipulation which provided false feedback about the future. The exclusionary procedure was design to protect participants in a potentially compromised emotional state. Previous research reported prevalence rates of loneliness around 10% of the sample (Hawkley & Cacioppo, 2010; Hawthorne, 2008), so a similar percentage was anticipated for this study. In the current sample, 43% of young adults (n = 40) and 42% of older adults (n = 42) were identified as lonely using the loneliness scale (see Table 1). This finding will be examined in the discussion.

Demographic Information and Cognitive Measures. Each participant completed a demographic survey that collected basic information including age, education, gender, race, occupation (or former occupation), marital status, and living situation. The response alternatives for the demographic questions are given in Appendix C. Vocabulary was assessed using a computerized version of the Shipley vocabulary test (Shipley, 1946). The test consists of 40 multiple choice items. Participants choose the synonym of the target word. For example, if the word is "large," participants must choose the best response from the following choices: 1) red 2) big 3) silent 4) wet. In this example, the answer is 2) big. The maximum score is 40. Participants were screened for color vision. Two young adult participants who were unable to distinguish colors did not complete the Stroop test.

The Trail Making Test (Reitan, 1958) was administered in two parts. The first part, Trails A, was administered following the vocabulary test; the second part, Trails B, was administered after the personality feedback and the priming manipulation, if it was administered. The baseline processing speed measure, Trails A, is an array of 25 numerically labeled dots randomly positioned on a piece of paper. Participants connected the dots in numerical order (1-2-3). The total time in seconds needed to complete the task was recorded. Longer times indicate slower processing speed. Trails B is an array of 25 dots labeled with either numbers (1-12) or letters (A-L), randomly positioned on a piece of paper. Again, the participants were timed as they connected the dots, this time alternating between number and letters (1-A-2-B-3-C-etc.). From the two parts, an interference score was calculated using the following formula: (Trails B – Trails A)/Trails A. Higher scores reflect more interference or less inhibitory control.

The Stroop test (Stroop, 1935) was administered in two parts. The first part, Stroop XXX, was administered after the Trails A; the second part was administered after the personality feedback and priming manipulation, if it was administered. In the baseline task, Stroop XXX, a measure of processing speed, participants had 45 seconds to verbally name the ink color (red, green, or blue) of blocks of X's. There were 5 columns each with 20 rows of blocks of colored Xs on a single page. The outcome measure was the number of correct responses. Fewer correct responses indicates slower processing speed. In the second task, Stroop Colors, the number of correct responses was recorded as participants named the

colors of the ink (red, green, or blue) of an incongruent color word (e.g., the word "GREEN" printed in red ink) for 45 seconds. Like the Trail Making Task, an interference score was calculated using the following formula: [(Stroop Colors - Stroop XXXs)/Stroop XXXs] * -1. The scores were inverted so the values for Stroop and Trail Making would be consistent; higher scores reflect more interference or less inhibitory control.

The reading span test (Daneman & Carpenter, 1980) was a measure of working memory; it is a robust predictor of reading comprehension and recall (Daneman & Mericle, 1996). For this task, participants read a sentence out loud and tried to remember the last word of the sentence. Sentences were presented in sets, starting with sets of 2 sentences; set size increased in length. At the end of a set, the participant attempted to recall the last word of each sentence in the order they were read. The participant's score was the length of longest set for which they could recall all the final words. For example, if the individual recalled the final words from all the sets of 4 sentences, their reading span was 4.

Comparison of Young and Older Adults. Young adults and older adults were significantly different on all of the demographic variables (see Table 2). Only 24% of the older adults were male while 42% of the young adults were male. Younger adults had less education, faster processing speeds (shorter Trails A completion time, more correct responses on Stroop XXX test), better working memories (larger reading spans), and smaller vocabularies than the older adults. Relationship status and living situations are reported in Table 3. The majority of young adults were single, never married (91%); about half of the older adults were in relationships (60%) and most of the remaining older adults were either divorced (17%), widowed (14%) or single, never married (9%). The majority of young adults were living with a roommate or in a group setting (84%) while older adults were most likely to be living with their spouse/partner (58%) or alone (33%).

Table 2.
Comparison of young adult and older adults.

	Young Adults		Older Adults	
	n = 93		*n* = 101	
	M	*SD*	*M*	*SD*
Age in years	19.11_a	.92	72.05_b	7.22
Gender (% female)	58_a		76_b	
Education[a]	1.20_a	.43	3.46_b	1.11
Loneliness	2.80	2.83	2.55	2.43
Trails A (s)	25.00_a	7.67	37.62_b	13.63
Stroop XXX (# items/ 45 s)	83.79_a	10.61	69.53_b	12.01
Reading Span (max = 7)	3.24_a	.81	2.80_b	.81
Vocabulary (max = 40)	29.55_a	3.77	35.71_b	2.60

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 3.
Living situation and relationship status for young adults and older adults.

	Young Adults	Older Adults
Relationship Status		
Single, never married	91%	9%
Married	0%	55%
Divorced	0%	17%
Widowed	0%	14%
Remarried	0%	3%
Committed Relationship	9%	2%
Living Situation		
Alone	10%	33%
With Roommate	70%	1%
With Spouse/Partner	0%	58%
With Dependent Children	1%	0%
With Family	5%	5%
In a Group Situation	14%	3%

De Jong Gierveld Loneliness Scale. The 11-item de Jong Gierveld Loneliness Scale (de Jong Gierveld, 1987) (DJG) was used to assess the current loneliness of individuals (see Table 4). Two advantages of the DJG Loneliness Scale are its development from the original Weiss definition and the availability of cutoffs to classify the presence and severity of loneliness. Emotional loneliness is a count of neutral and positive responses ("more or less", "yes", or "yes!") on items 2, 3, 5, 6, 9, and 10. Social loneliness is a count of neutral and negative responses ("no!", "no", or "more or less") answers on items 1, 4, 7, 8, and 11. Loneliness scoring cutoffs have been developed for the composite scores (van Tilburg & de Jong Gierveld, 1999). Individuals with scores from 0 - 2 were considered non-lonely; individuals with scores from 3 - 8 were moderately lonely; individuals with scores greater than 8 were severely lonely. Participants with scores equal to or greater than 3 on the scale were excluded from the future priming manipulation; this was discussed in the section on exclusionary criteria (p. 20).

Non-lonely and Lonely Comparisons. Non-lonely and lonely participants were compared for baseline demographic and cognitive differences (see Tables 5 and 6). In the young adult sample, there was a significant effect of age, t (91) = -2.24, $p < .05$; the non-lonely group was younger (M = 18.92, SD = .76) than the lonely group (M =19.35, SD = 1.07). However, lonely and non-lonely young adults did not differ on other baseline demographic and cognitive measures. The lonely and non-lonely older adults did ot differ in age, education, reading span or vocabulary. There was a significant effect of gender, t (99) = -2.43, $p < .05$, with more women than men in the non-lonely group. Additionally, the lonely older adults were significantly slower than non-lonely older adults on both speed measures, Trails A, t (99) = -3.34, $p < .01$, and the Stroop XXX, t (99) = 2.77, $p < .01$.

Table 4.

The de Jong Gierveld Loneliness Scale.

Instructions. *Please indicate for each of the statements, the extent to which they apply to your situation, the way you feel now. Please circle the answer that is appropriate to you.*						
Item		Response Alternatives				
1.	There is always someone I talk to about my day-to-day problems.	yes!	yes	more or less	no	no!
2.	I miss having a really close friend.	yes!	yes	more or less	no	no!
3.	I experience a general sense of emptiness.	yes!	yes	more or less	no	no!
4.	There are plenty of people I can rely on when I have problems.	yes!	yes	more or less	no	no!
5.	I miss the pleasure of the company of others.	yes!	yes	more or less	no	no!
6.	I find my circle of friends and acquaintances too limited.	yes!	yes	more or less	no	no!
7.	There are many people I can trust completely.	yes!	yes	more or less	no	no!
8.	There are enough people I feel close to.	yes!	yes	more or less	no	no!
9.	I miss having people around.	yes!	yes	more or less	no	no!
10.	I often feel rejected.	yes!	yes	more or less	no	no!
11.	I can call on my friends whenever I need them.	yes!	yes	more or less	no	no!

Note. From de Jong Gierveld, J & Van Tilburg, T (2006). A 6-item scale for overall, emotional, and social loneliness: confirmatory tests on survey data. *Research on Aging, 28*(5), 582-598.

Table 5.
Comparison of non-lonely and lonely young adults.

	Non-lonely		Lonely	
	n = 53		*n* = 40	
	M	*SD*	*M*	*SD*
Age in years	18.92_a	.76	19.35_b	1.07
Gender (% female)	66		48	
Education[a]	1.17	.38	1.25	.49
Trails A (s)	24.72	7.68	25.38	7.73
Stroop XXX (# items/ 45 s)	84.04	10.79	83.45	10.49
Reading Span (max = 7)	3.32	.77	3.13	.85
Vocabulary (max = 40)	29.28	3.38	29.90	4.25
Average Reading Time (s)	223.93	59.76	238.20	71.75

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 6.
Comparison of non-lonely and lonely older adults.

	Non-Lonely		Lonely	
	n = 59		*n* = 42	
	M	*SD*	*M*	*SD*
Age in years	70.90	6.88	73.67	7.46
Gender (% female)	85_a		64_b	
Education[a]	3.53	1.06	3.36	1.19
Trails A (s)	33.98_a	11.30	42.74_b	15.05
Stroop XXX (# items /45 s)	72.24_a	10.40	65.74_b	13.17
Reading Span (max = 7)	2.82	.81	2.76	.83
Vocabulary (max = 40)	35.78	2.24	35.62	3.06
Average Reading Time (s)	256.17	79.15	285.69	105.62

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Loneliness severity comparisons. To check for baseline differences between participants differing in loneliness severity, the loneliness scores were divided into three severity groups: 0-2, 3-7, and 8-11 following van Tilburg & de Jong Gierveld (1999). Higher scores indicated greater loneliness. A summary of the DJG Scale results is in Table 7. Figure 1 shows the distribution of young adults and older adults based on their DJG loneliness scale score. There were no significant differences between the loneliness scores of young adults (M = 2.80, SD = 2.83) and older adults (M = 2.55, SD = 2.43). There were no significant demographic differences among young adults as a function of loneliness severity; see Table 8 for the means and standard deviations. Table 9 reports means and standard deviations for the older adults. Loneliness severity was associated with female gender, F (2, 98) = 2.92, p = 0.06, and slower processing speed for the older adults , Trails A, F (2, 98) = 6.98, $p < 0.01$, and Stroop XXX, F (2, 98) = 5.12, $p < 0.01$.

Table 7.

Comparison of young and older adults on the DJG Loneliness Scale scores.

	Young Adults		Older Adults	
	M	*SD*	*M*	*SD*
All Participants	2.80	2.83	2.55	2.43
Scores $\leq$ 2	.74	.84	.93	.81
Scores $\geq$ 3	5.53	2.15	4.83	2.08
Scores 3-7	4.58	1.31	4.38	1.33
Scores 8+	8.78	.83	10.67	.58

Note. Row entries entries with different subscripts differ at $p < 0.05$.

Figure 1. Distribution of participants based on loneliness scores from DJG Loneliness Scale.

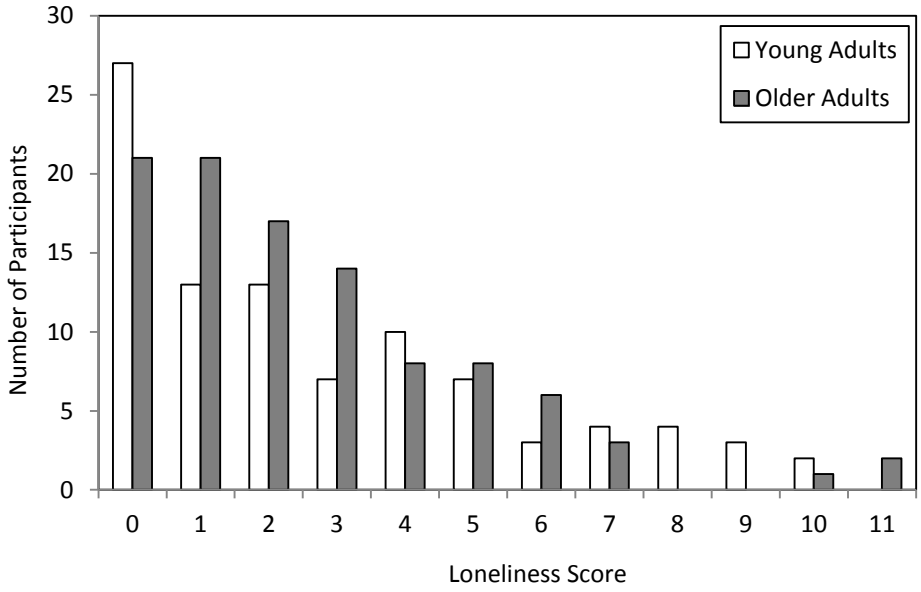


Table 8.
Comparison of young adults by loneliness severity.

DJG Scale Score	0-2		3-7		8-11	
	n = 53		*n* = 31		*n* = 9	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age in years	18.92	.76	19.39	1.12	19.22	.97
Gender (% female)	66		52		33	
Education[a]	1.17	.38	1.26	.51	1.22	.44
Trails A (s)	24.72	7.69	26.23	8.16	22.44	5.41
Stroop XXX (# items/ 45 s)	84.04	10.79	83.21	11.52	84.22	6.59
Reading Span (max = 7)	3.32	.77	3.10	.81	3.22	1.06
Vocabulary (max = 40)	29.28	3.38	29.74	4.34	30.44	4.10
Average Reading Time (s)	223.93	59.76	231.38	67.91	252.35	80.10

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 9.
Comparison of older adults by loneliness severity.

DJG Scale Score	0-2		3-7		8-11	
	n = 59		*n* = 39		*n* = 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age in years	70.90	6.88	73.36	7.30	77.67	10.21
Gender (% female)	85_a		64_b		$67_{a,b}$	
Education[a]	3.53	1.06	3.38	1.16	3.00	1.73
Trails A (s)	33.98_a	11.30	41.85_b	15.24	54.33_c	3.79
Stroop XXX (# items/ 45 s)	72.24_a	10.40	66.51_b	13.18	55.67_b	9.50
Reading Span (max = 7)	2.82	.81	2.80	.84	2.33	.58
Vocabulary (max = 40)	35.78	2.24	35.95	2.61	31.33	5.77
Average Reading Time (s)	256.17	79.15	288.19	106.37	271.11	109.61

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Relationships between demographic, cognitive, and loneliness measures. Correlations were computed to examine the relationships between the demographic, cognitive and loneliness measures. To avoid spurious correlations caused by the large group mean differences on these measures, separate correlations were computed for the young adults and the older groups (Hofer, Flaherty, & Hoffman, 2006). These results are summarized in Table 10. There were few significant correlations among the variables in the young adult sample. Age was positively correlated with education. Males were more likely to have higher loneliness scores and higher vocabulary scores than women. Performance on the speed measures, Stroop XXX and Trails A, were correlated. Stroop XXX was also correlated with reading span; those who gave more correct responds on Stroop XXX were more likely to have larger reading spans.

Demographic, cognitive, and loneliness variables were more likely to be correlated for the older participants. Age was correlated with all variables except gender; older adults were slower, had reduced working memory and reading spans, less education, and greater loneliness. Gender was correlated with education, loneliness, and processing speed. Males were better educated, had higher loneliness scores, and were slower than females. Education was correlated with reading span and vocabulary. Participants with more education had larger reading spans and vocabularies. Loneliness was negatively correlated with processing speed on both Trails A and Stroop XXX. And the processing speed and reading span scores were positively correlated.

Table 10.
Correlations among demographic, cognitive, and loneliness measures for young adults (lower half-matrix) and older adults (upper half-matrix).

	1.	2.	3.	4.	5.	6.	7.	8.
1. Age		.061	-.308**	.251*	.464**	-.442**	-.231*	-.320**
2. Gender (% female)	-.005		.233*	.228*	.201*	-.006	-.119	.179
3. Education	.380**	-.100		-.091	-.092	.143	.226*	.507**
4. DJG Scale	.182	.208*	.052		.384**	.291**	-.097	-.149
5. Trails A	.044	.203	.030	.040		.448**	-.330**	-.260**
6. Stroop XXX	-.131	.150	-.145	.002	.238*		.274**	.199*
7. Reading Span	.031	.048	.172	-.055	-.026	.230*		.358**
8. Vocabulary	-.008	.265*	.024	.154	.008	.033	.143	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Note. Intercorrelations for young adults (n = 93) are presented below the diagonal, and intercorrelations for older adults (n = 101) are presented above the diagonal.

5. Ten Item Personality Inventory. The Ten Item Personality Inventory (TIPI) is a brief ten-item measure derived from a longer personality inventory (Gosling, Rentfrow, & Swann, 2003). Participants were asked to report how much they identify with pairs of personality traits, for example, "reserved, quiet" (see Table 11). The inventory has been correlated with longer inventories such as the Big Five Inventory (Gosling et al., 2003). For example, the extraversion scale of the Big Five Inventory is highly correlated with the extraversion scale of the TIPI (r = *.87*). Baumeister et al. (2002) used a personality inventory to provide accurate feedback about participants' trait extraversion to increase the credibility of the false feedback designed to prime loneliness. In the current research, all participants were given the same personality feedback about being both a combination of extraverted and introverted traits. The feedback was general enough so most individuals related to the feedback. The personality of the participant was not scored during the testing session and had no impact on the personality feedback that was given to each participant (included below).

Personality Feedback

Based on your answers from the personality inventory, you are both extraverted and introverted. The score suggests that you may enjoy interacting with people, can articulate your perspective well, and may prefer some solitude or quiet. As a combination, you can be both enthusiastic and calming. You are self-confident, a good listener and someone who engages with the world using a mix of restraint and boldness.

Comparison of Young and Older Adults. In comparisons of young adults and older adults (see Table 12), there was a significant effect of agreeableness, t (192) = -4.65, $p < 0.01$, with young adults reporting less agreeableness than older adults. There was also a significant effect of emotional stability, t (192) = -2.74, $p < 0.01$, with young adults reporting less emotional stability than older adults. Within age group comparisons of non-lonely and lonely adults were conducted (Tables 13 and 14). For young adults, there were significant effects of extraversion, t (91) = 3.86, $p < 0.01$; agreeableness, t (91) = 3.29, $p < 0.01$; conscientiousness, t (91) = 2.87, $p < 0.01$; and emotional stability, t (91) = 2.20, $p < 0.05$. Non-lonely young adults were more extraverted, more agreeable, more conscientious, and more emotionally stable than lonely young adults. Non-lonely and lonely young adults did not differ significantly on openness to new experience. For older adults, there were significant effects of agreeableness, t (99) = 2.01, $p < 0.05$; conscientiousness, t (99) = 3.10, $p < 0.01$; and openness to new experiences, t (99) = 2.13, $p < 0.05$. Non-lonely older adults were more agreeable, more conscientious, and more open to new experiences than lonely older adults. Non-lonely and lonely older adults did not differ significantly on extraversion or emotional stability.

Table 11.
The Ten Item Personality Inventory.

Instructions: *Here are a number of personality traits that may or may not apply to you. Please circle the number next to each statement to indicate the extent to which* you agree or disagree *with that statement. You should rate the extent to which the pair of traits applies to you even if one of the characteristics applies more strongly than the other.*

Item		Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	Extraverted, enthusiastic.	1	2	3	4	5	6	7
2	Critical, quarrelsome.	1	2	3	4	5	6	7
3	Dependable, self-disciplined.	1	2	3	4	5	6	7
4	Anxious, easily upset.	1	2	3	4	5	6	7
5	Open to new experiences, complex.	1	2	3	4	5	6	7
6	Reserved, quiet.	1	2	3	4	5	6	7
7	Sympathetic, warm.	1	2	3	4	5	6	7
8	Disorganized, careless.	1	2	3	4	5	6	7
9	Calm, emotionally stable.	1	2	3	4	5	6	7
10	Conventional, uncreative.	1	2	3	4	5	6	7

Note. From Gosling, S.D., Rentfrow, P.J., & Swann, W.B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality, 37*(6), 504-528.

Table 12.
Comparison of young and older adults on the 5 scales derived from the Ten Item Personality Inventory.

	Young Adults		Older Adults	
	M	*SD*	*M*	*SD*
Extraversion	8.90	3.04	8.89	2.99
Agreeableness	9.19_a	2.40	10.73_b	2.22
Conscientiousness	11.18	1.99	11.17	2.65
Emotional Stability	9.53_a	2.54	10.53_b	2.58
Openness	10.30	2.29	10.49	2.35

Note. Row entries entries with different subscripts differ at $p < 0.05$.

Table 13.
Comparison of non-lonely and lonely young adults on the 5 scales assessed by the Ten Item Personality Inventory.

	Non-Lonely		Lonely	
	M	*SD*	*M*	*SD*
Extraversion	9.89_a	2.74	7.60_b	2.95
Agreeableness	9.87_a	1.90	8.03_b	2.70
Conscientiousness	11.68_a	1.59	10.53_b	2.29
Emotional Stability	10.02_a	2.23	8.88_b	2.78
Openness	10.53	2.00	10.00	2.62

Note. Row entries entries with different subscripts differ at $p < 0.05$.

Table 14.
Comparison of non-lonely and lonely older adults for the 5 scales assessed by the Ten Item Personality Inventory.

	Non-Lonely		Lonely	
	M	*SD*	*M*	*SD*
Extraversion	9.02	2.93	8.71	3.10
Agreeableness	11.10_a	2.12	10.21_b	2.27
Conscientiousness	11.83_a	2.30	10.24_b	2.86
Emotional Stability	10.90	2.20	10.02	2.98
Openness	10.90_a	2.00	9.90_b	2.68

Note. Row entries entries with different subscripts differ at $p < 0.05$.

Relationships between personality traits and loneliness. Correlations were computed to examine the relationships between the personality traits and loneliness scores. These results are summarized in Table 15. Young adults who were more agreeable also tended to be more conscientious and emotionally stable. The more conscientious a young adult was the more likely they were to be emotionally stable. Young adults open to new experiences were more extraverted and emotionally stable. Young adults who are more extraverted, agreeable, conscientious, and emotionally stable tend to be less lonely. Similar to

the young adults, older adults who were more agreeable also tended to be more conscientious and emotionally stable; the more conscientious the older adult was the more likely they were to be emotionally stable. Again mirroring the young adults, older adults open to new experiences were more extraverted and emotionally stable. Older adults who are more agreeable, conscientious, and emotionally stable tend to be less lonely.

Table 15.
Correlations between personality traits among young adults (lower half-matrix) and older adults (upper half-matrix).

	1.	2.	3.	4.	5.	6.
1. Extraversion		.118	.051	.189	.217*	-.166
2. Agreeableness	.044		.302**	.265**	.142	-.240*
3. Conscientiousness	.080	.261*		.407**	.171	-.274**
4. Emotional Stability	-.051	.233*	.308**		.440**	-.338**
5. Openness to New Experience	.297**	-.084	.074	.244*		-.171
6. DJG Scale	-.292**	-.329**	-.384**	-.309**	-.005	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Note. Intercorrelations for young adults (n = 93) are presented below the diagonal, and intercorrelations for older adults (n = 101) are presented above the diagonal.

Reading Passages and Reading Comprehension. Reading comprehension was assessed on two passages taken from the reading comprehension section of a SAT pretest (Mathur, 2012) (see Appendix D). Participants read the passages after the reading span test and before the personality feedback and the priming manipulation, if administered. The order of the passages was counterbalanced across participants. Flesch-Kincaid Readability of both passages is equivalent to Grade 12. One was 412 words in length; the other 832 words. Average reading time for young adults was M = 230.07 seconds (SD = 65.21); for older adults, M = 268.27 seconds (SD = 91.60). Reading times for young adults were similar in all 4 conditions (future alone, future belonging, future misfortune, no prime) on the *Social Function of Science* passage F (3, 92) = 1.27, p = 0.29, and on the *Voyage of the Beagle* passage, F (3, 92) = 1.20, p = 0.31; reading times for older adults in the 4 conditions were also similar for both the *Social Function of Science*

passage, F (3, 99) = .98, p = 0.41, and the *Voyage of the Beagle* passage, F (3, 99) = 1.14, p = 0.21. There were no significant differences between the non-lonely and lonely adults, regardless of age group, for reading time (t_{YA} (91) = -1.05, p = .30; t_{OA} (98) = -1.60, p = .11).

The reading comprehension test, an outcome measure, was completed after the priming manipulation, if administered, and after the Trails B and Stroop Colors tests were administered. The participants completed the reading comprehension task on a computer; questions were blocked by passage and the blocks of questions were presented in the same order as the passages. Reading comprehension was tested with 7 comprehension questions per passage, also taken from the SAT pretest[1]. A total was calculated across passages for a total of 14 comprehension questions. Young adults answered an average of 46% (n = 6.5) of the questions correctly; older adults answered 54% (n = 7.5) of the questions correctly.

Personality and Priming Feedback. The three false future primes were adapted from the original study by Baumeister, Twenge, and Nuss (2002) to better generalize to both young and older adults. Each prime is included below; the original primes are included in Appendix E. The different primes are similar in length and structure. Lonely participants, based on the DJG Loneliness Scale score, were excluded from the priming manipulation. Lonely participants received the personality feedback to approximate the delay the primed participants experienced before taking the executive function tasks and reading comprehension task.

[1] Three potential SAT passages with extra comprehension questions and response alternatives were pilot tested on a group of 6 young adults. They answered 43% of the comprehension questions correctly. Based on their responses, two passages were chosen; the number of comprehension questions per passage was reduced to seven; the number of multiple choice alternatives was reduced from five choices to four choices. Questions that no one answered correctly were dropped. The revised materials were tested on an additional group of 6 young adults. Average reading time on the *Social Function of Science* passage (412 words) was M = 132.42 seconds (SD = 17.09) ; average reading time on the *Voyage of the Beagle* passage (832 words) was M = 223.58 seconds (SD = 54.17). Overall average reading speed was 205 words per minute. These young adults answered 60% of the reading comprehension questions correctly. The *Social Function of Science* passage is shorter and young adults answered more questions correctly (64%), compared their comprehension of the *Voyage of the Beagle* passage (55%). The comprehension questions avoided both ceiling and floor effects; comprehension accuracy ranged from 21% correct to 90% correct (averaged over the 2 passages).

Future Alone Prime Condition

Research suggests that your score is consistent with people who end up alone. You may have friends and relationships now, but later in your life most of these will have ended or drifted away. You may have close relationships, but these are likely to be short-lived or not continue for your entire life. Relationships don't last, and soon, when you're past the age when people easily form new relationships, the odds are you'll end up being alone more and more.

Future Belonging Prime Condition

Research suggests that your score is consistent with people who maintain relationships throughout life. You have friends and relationships now, and are more likely to maintain long, stable relationships. You have rewarding relationships, and these are likely to last for your entire life. Relationships will last, and even when you're past the age when people easily form new relationships, the odds are you'll always have friends and people who care about you.

Future Misfortune Prime Condition

Research suggests that your score is consistent with people who are accident prone later in life. You may not have a history of accidents now, but are more likely to experience falls or injuries. You will have increased risk for bodily harm doing your everyday activities; this risk is also likely to increase for car accidents. Even if you haven't been accident-prone before, these things will show up later in life, and the odds are you will have accidents.

Prime Condition Comparisons. Participants assigned to the four prime conditions (future alone, future belonging, and future misfortune, no prime) were compared using a series of one-way ANOVAs; see Tables 16 and 17 for means and standard deviations. Young adults in the 4 groups did not differ significantly in age, F (3, 92) = 1.70, p 0.17, or education, F (3, 92) = 1.66, p = 0.18. There was a significant difference between conditions for gender, F (3, 92) = 2.77, $p < 0.05$; there were more women

than men assigned to the future belonging condition than the future alone or no prime conditions. The young adults did not differ on the baseline cognitive measures: Trails A, F (3, 92) = .66, p = 0.58; Stroop XXX, F (3, 90) = .25, p = 0.86; reading span, F (3, 92) = .98, p = 0.41; and vocabulary, F (3, 92) = .574, p = 0.63. Older adults in the 4 groups did not differ significantly in age, F (3, 100) = 1.47, p = 0.22; education, F (3, 100) = 1.43, p = 0.24; or gender, F (3, 100) = 2.10, p = 0.11. Older adults in the 4 groups did differ significantly in processing speed, Trails A, F (3, 100) = 4.36, $p < 0.01$ and Stroop XXX, F (3, 100) = .3.69, p = 0.014. Lonely older adults who were not given a future prime were significantly slower on Trails A and produced significantly fewer correct responses on Stroop XXX than the older adults in the future alone condition or the future belonging condition. Older adults in the 4 groups did not differ significantly in reading span, F (3, 100) = 1.22, p = 0.31, or vocabulary, F (3, 100) = .379, p = 0.77.

Non-lonely participants were randomly assigned to one of three future prime conditions (future alone, future belonging, and future misfortune). Young adults in the 3 prime conditions did not differ significantly on any of the demographic or cognitive variables: age, F (2, 50) = .13, p = 0.88; Trails A, F (2, 50) = .90, p = 0.41; Stroop XXX, F (2, 50) = .33, p = 0.72; reading speed, F (2, 50) = .88, p = 0.42; or vocabulary, F (2, 50) = .70, p = 0.50. The older adults in the 3 prime conditions did not differ significantly on any of the variables: age, F (2, 58) = .40, p = 0.67; Trails a, F (2, 58) = 1.28, p = 0.29; Stroop XXX, F (2, 58) = 2.12, p = 0.13; reading speed, F (2, 58) = .1.81, p = 0.17; or vocabulary, F (2, 58) = .71, p = 0.50. The means and standard deviations for young adults are reported in Table 18; those for older adults are reported in Table 19.

Table 16.
Comparison of young adults by prime condition.

	Alone		Belong		Misfortune		None	
	n = 17		*n* = 18		*n* = 18		*n* = 40	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age in years	18.88	.49	18.89	.58	19.00	1.09	19.35	1.08
Gender (% female)	47_{a}		83_{b}		$67_{a,b}$		48_{a}	
Education[a]	1.12	.33	1.33	.49	1.06	.24	1.25	.49
Trails A (s)	26.76	9.43	24.00	5.48	23.50	7.78	25.38	7.73
Stroop XXX (# items/ 45 s)	85.71	11.82	82.78	9.62	83.72	11.29	83.45	10.49
Reading Span (max = 7)	3.12	.55	3.42	.84	3.42	.86	3.13	.85
Vocabulary (max = 40)	29.88	3.23	28.56	3.68	29.44	3.24	29.90	4.25
Average Reading Time (s)	202.42	48.47	237.84	76.60	230.33	46.20	238.20	71.75

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 17.
Comparison of older adults by prime condition.

	Alone		Belong		Misfortune		None	
	n = 19		*n* = 20		*n* = 20		*n* = 42	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age in years	70.74	7.02	70.00	5.41	71.95	8.15	73.67	7.46
Gender (% female)	89_{a}		85_{a}		80_{a}		64_{b}	
Education[a]	3.42	1.02	3.90	.91	3.25	1.16	3.36	1.19
Trails A (s)	32.11_{a}	9.16	32.50_{a}	12.15	37.25_{a}	12.06	42.74_{b}	15.05
Stroop XXX (# items/ 45 s)	75.68_{a}	8.07	72.25_{a}	10.55	68.95_{a}	11.57	65.74_{b}	13.17
Reading Span (max = 7)	3.11	.79	2.73	.80	2.65	.80	2.76	.82
Vocabulary (max = 40)	35.42	2.41	36.25	2.05	35.65	2.30	35.62	3.06
Average Reading Time (s)	242.93	80.30	268.77	90.69	256.14	66.70	285.69	105.62

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 18.
Comparison of non-lonely young adults assigned to 3 loneliness prime conditions.

	Alone		Belong		Misfortune	
	n = 17		*n* = 18		*n* = 18	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age in years	18.88	.49	18.89	.58	19.00	1.09
Gender (% female)	47		83		67	
Education[a]	1.12	.33	1.33	.49	1.06	.24
Trails A (s)	26.76	9.44	24.00	5.48	23.50	7.78
Stroop XXX (# items/45 s)	85.71	11.82	82.78	9.62	83.72	11.30
Reading Span (max = 7)	3.12	.55	3.42	.84	3.42	.86
Vocabulary (max = 40)	29.88	3.24	28.56	3.68	29.44	3.24

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 19.
Comparison of non-lonely older adults assigned to 3 loneliness prime conditions.

	Alone		Belong		Misfortune	
	n = 19		*n* = 20		*n* = 20	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age in years	70.74	7.02	70.00	5.41	71.95	8.15
Gender (% female)	89		85		80	
Education[a]	3.42	1.02	3.90	.91	3.25	1.16
Trails A (s)	32.11	9.16	32.50	12.15	37.25	12.06
Stroop XXX (# items/ 45 s)	75.68	8.07	72.25	10.55	68.95	11.57
Reading Span (max = 7)	3.11	.79	2.73	.80	2.65	.80
Vocabulary (max = 40)	35.42	2.41	36.25	2.05	35.65	2.30

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Cognitive Age. Participants completed a short cognitive age questionnaire, an outcome measure, following the executive function tasks. The four item measure was included assess if the primes affected the participants self-perception of their cognitive age. Participants were asked to select which the age that best matched their self-perception (I FEEL as though I am in my….; I LOOK as though I am in my….; I DO most things as though I were in my….; My interests are those of a person in his/her….). The response alternatives were organized by decade (teens, 20s, 30s, 40s) and choices were ordered such that a response of 1 = teens; 2 = 20s; 3 = 30s, etc. The answers from the 4 items were averaged. Young adults reported that they typically felt either in their teens or 20s (M_{YA} = 1.65, *SD* = .47); older adults reported, on average, feeling in their 60s (M_{OA} = 5.70, *SD* = .89). However older adults did have more variability in their actual ages, therefore more variability was expected in their perceived ages Discrepancy scores were calculated by subtracting the actual age from the individuals average perceived cognitive age (Edwards, 1994). Larger scores, farther from zero, indicate more discrepancy. Negative values indicate that the actual age is older than the perceived age; positive values indicate the perceived age is older than the actual age. As a caveat for these scores, choices about perceived age were expressed in decades. Therefore, 18 year old young adults may have chosen 1, indicating "teens," which would give them a discrepancy score of -8. There was a significant effect of age discrepancy, t (192) = 15.03, $p < .01$, with older adults (M_{OA} = -15.09, *SD* = 6.7) reporting larger ages discrepancies than young adults (M_{YA} = -2.63, *SD* = 4.53).

Probe Questions and Debriefing. At the conclusion of the study, the experimenter asked a series of questions probing to check for possible sources of bias, fully debriefed the participant, and answered any remaining questions the participant had about the study. Participants responded orally to the questions and all responses were audio recorded. See Appendix B for the probe questions and debriefing script.

The probe questions were used to determine if participants had any suspicions regarding the loneliness primes, had heard about the experiment from a prior participant, thought that their answers on one task affected their performance on another task, or felt that they were being deceived or manipulated.

Participants who expressed any suspicions, doubts, or disbeliefs were coded as a "1" for "doubters." All others were coded as "0" for "believers." The distribution of doubters and believers within different conditions was similar for young and older adults (see Table 20). *T*-tests assessed possible baseline differences between the believers and the doubters (see Tables 21 and 22). For young adults, there was a significant effect for age, t (91) = 1.99, p = .05, with believers being somewhat older than the doubters. There were no other significant demographic differences between the believers and doubters[2]. Since believing the loneliness prime should increase the likelihood of behavior change, a series of one-way ANOVAs examined the outcome measures for believers only (n_{YA} = 65; n_{OA} = 77); the pattern of results mirrored those from the full data set (see Appendix F); therefore, all following reported analyses are conducted with the full data set (n_{YA} = 93; n_{OA} = 101) to increase power to detect small effects.

Table 20.
The distribution of participants who doubted or believed the loneliness prime.

	Young Adults		Older Adults	
	Believers	Doubters	Believers	Doubters
	n = 65	n = 28	n = 77	n = 24
Alone Prime	41%	59%	47%	53%
Belonging Prime	94%	6%	100%	0%
Misfortune Prime	56%	44%	55%	45%
No Prime	77%	23%	88%	12%

[2] The personality traits of doubters and believers were compared using the extraversion, agreeableness, conscientiousness, emotional stability, and openness to new experience scores from the Ten Item Personality Inventory. Believers and doubters were not significantly different on any of the personality traits, regardless of age: extraversion, t (192) = .843, p = .40; agreeableness, t (192) = .716, p = .48; conscientiousness, t (192) = .420, p = .68; emotional stability, t (192) = .728, p = .47; and openness to new experience, t (192) = .604, p = .55. None of the personality traits were correlated with whether or not a participant, regardless of age, believed the personality feedback or future priming manipulation.

Table 21.
Comparison of young adults who doubted or believed the loneliness prime.

	Believers		Doubters	
	n = 65		*n* = 28	
	M	*SD*	*M*	*SD*
Age in years	19.23_a	.97	18.82_b	.77
Gender (% female)	52		71	
Education[a]	1.22	.45	1.18	.39
Trails A (s)	25.18	7.79	24.57	7.50
Stroop XXX (# items/45 s)	84.83	9.75	81.46	12.20
Reading Span (max = 7)	3.32	.85	3.04	.67
Vocabulary (max = 40)	29.63	3.80	29.36	3.74

Note. Row entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Table 22.
Comparison of older adults who doubted or believed the loneliness prime.

	Believers		Doubters	
	n = 77		*n* = 24	
	M	*SD*	*M*	*SD*
Age in years	72.03	7.13	72.13	7.65
Gender (%female)	77		75	
Education[a]	3.45	1.12	3.46	1.10
Trails A (s)	37.96	13.82	36.54	13.22
Stroop XXX (# items/ 45 s)	69.08	12.14	71.00	11.70
Reading Span (max = 7)	2.77	.81	2.88	.85
Vocabulary (max = 40)	35.65	2.69	35.92	2.34

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Education was coded on 6-point scale where 0 = not high school graduate, 1 = high school graduate, 2 = some college or associate degree, 3 = bachelor's degree, 4 = master's degree, and 6 = doctoral or other terminal degree.

Chapter 4. Results

The analysis proceeded in four stages: First, non-lonely and lonely participants within age groups were compared; second, the effect of loneliness severity within age group was investigated; third, within age group comparisons of the four experimental conditions (future alone, future belonging, future misfortune, and no prime) were made; the final analysis examined the effect of the three priming manipulations on young versus older adults. Each set of analyses examined 4 outcome measures: Trails Making interference, Stroop interference, reading comprehension, and cognitive age.

Non-Lonely versus Lonely Comparisons.

Non-lonely and lonely young adults and older adults were compared using a series of *t*-tests; results are reported in in Tables 23 and 24. There were no significant differences between the non-lonely and lonely adults, regardless of age group, on Trail Making interference (t_{YA} (91) = -.46, p = .65; t_{OA} (96) = -.08, p = .94); Stroop interference (t_{YA} (89) = .69, p = .49; t_{OA} (97) = -.71, p = .48); or reading comprehension (t_{YA} (91) = -.50, p = .62; t_{OA} (97) = .87, p = .39). There was a significant difference between the cognitive age of the non-lonely and lonely young adults, t (91) = -2.20, $p < .05$, with non-lonely adults reporting younger cognitive ages than the lonely adults. Loneliness did not affect older adults' perceived cognitive age, t (99) = .72, p = .47.

Table 23.
Comparison of non-lonely and lonely young adults on the outcome measures.

	Non-lonely		Lonely	
	n = 53		*n* = 40	
	M	*SD*	*M*	*SD*
Trails Interference[a]	1.35	.69	1.29	.50
Stroop Interference[a]	0.25	.09	0.23	.09
Reading Comprehension	6.38	2.22	6.60	2.05
Average Cognitive Age	1.56_a	.41	1.77_b	.52

Note. Row entries entries with different subscripts differ at $p < 0.05$. 5.
[a]Higher scores indicate greater interference.

Table 24.

Comparison of non-lonely and lonely older adults on the outcome measures.

	Non-lonely		Lonely	
	n = 59		*n* = 42	
	M	*SD*	*M*	*SD*
Trails Interference[a]	1.33	.68	1.34	.75
Stroop Interference[a]	0.42	.12	0.44	.14
Reading Comprehension	7.69	2.82	7.20	2.69
Average Cognitive Age	5.75	.86	5.62	.95

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Higher scores indicate greater interference.

Loneliness Severity Comparisons.

The effect of loneliness severity on the outcome measures is reported in Tables 25 and 26. There were no significant differences due to loneliness severity, regardless of age group, on Trail Making interference (F_{YA} (2, 90) = .33, p = .72; F_{oa} (2, 95) = .07, p = .93) or Stroop interference (F_{YA} (2, 88) = .57, p = .57; F_{OA} (2,96) = .48, p = .62). Loneliness severity did not affect young adults' reading comprehension, F (2, 90) = .21, p = .81. There was a marginally significant effect of loneliness severity on young adults' perceived cognitive age, F (2, 90) = 3.03, p = .053, with the loneliest young adults reporting higher cognitive ages than non-lonely young adults. There was a significant effect of loneliness severity on older adults' reading comprehension, F (2, 98) = 3.17, $p < .05$, with the loneliest older adults answering fewer comprehension questions correctly than the other groups of older adults. Loneliness severity did not affect older adults' perceived cognitive age, F (2, 98) = .29, p = .71.

Table 25.

Comparison of young adults on the outcome measures by loneliness severity.

DJG Scale Score	0-2		3-7		8-11	
	n = 53		*n* = 31		*n* = 9	
	M	*SD*	*M*	*SD*	*M*	*SD*
Trails Interference[a]	1.35	.69	1.25	.50	1.41	.56
Stroop Interference[a]	0.25	.09	0.23	.08	0.26	.11
Reading Comprehension	6.38	2.22	6.56	2.03	6.69	2.18
Average Cognitive Age	1.56	.41	1.74	.45	1.83	.67

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Higher scores indicate greater interference.

Table 26.

Comparison of older adults on the outcome measures by loneliness severity.

DJG Scale Score	0-2		3-7		8-11	
	n = 59		*n* = 39		*n* = 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Trails Interference[a]	1.33	.68	1.35	.76	1.20	.75
Stroop Interference[a]	0.42	.12	0.44	.13	0.49	.22
Reading Comprehension	7.69_a	2.82	7.46_a	2.56	5.40_b	3.21
Average Cognitive Age	5.75	.86	5.58	.89	5.83	1.33

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Higher scores indicate greater interference.

Comparison of 4 experimental conditions.

Comparisons of young and older adults assigned to the 4 experimental conditions (future alone, future belonging, future misfortune, no prime) are reported in Tables 27 and 28. In one-way ANOVAs with all four possible prime conditions, there were no significant differences for young adults on Trail Making interference, F (3, 89) = .33, p = .80, or Stroop interference, F (3, 87) = .25, p = .86, nor for older adults, Trail Making interference, F (3, 94) = .70, p = .55, and Stroop interference, F (3, 95) = .32, p =

.81. There were no significant differences for young adults' reading comprehension, F (3, 89) = 1.71, p = .17, or for older adults' reading comprehension, F (3, 95) = 2.13, p = .10. Finally, there were no significant differences for young adults' cognitive age, F (3, 89) = .34, p = .20, or older adults' cognitive age, F (3, 97) = .90, p = .45.

Table 29 provides the correlations among the outcome measures for young adults and older adults. There were few significant correlations among the outcome measures for young adults. Young adults who read more rapidly had less interference on the Stroop task. Young adults with higher scores on the DJG Scale had older cognitive ages. For the older adults, higher cognitive ages were correlated with less interference on both the Stroop and Trail Making measures. Better reading comprehension was correlated reduced interference on the Stroop measure; better reading comprehension was also correlated with lower cognitive age in older adults. Finally, less interference on the Trail Making task was correlated with faster reading speeds on the passages.

Table 27.

Comparison of young adults on the outcome measures by prime condition.

	Alone		Belong		Misfortune		None	
	n = 17		n = 18		n = 18		n = 40	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Trails Interference[a]	1.25	.73	1.40	.73	1.42	.64	1.29	.50
Stroop Interference[a]	0.24	.11	0.25	.10	0.26	.06	0.23	.09
Reading Comprehension	7.24	2.41	5.67	2.03	6.28	2.05	6.60	2.05
Average Cognitive Age	1.54	.35	1.56	.49	1.57	.39	1.77	.52

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Higher scores indicate greater interference.

Table 28.

Comparison of older adults on the outcome measures by prime condition.

	Alone		Belong		Misfortune		None	
	n = 19		*n* = 20		*n* = 20		*n* = 42	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Trails Interference[a]	1.21	.59	1.52	.75	1.26	.68	1.34	.75
Stroop Interference[a]	0.40	.14	0.43	.12	0.43	.12	0.44	.14
Reading Comprehension	7.26	2.21	8.85	3.28	6.95	2.59	7.20	2.69
Average Cognitive Age	5.66	.59	5.60	.65	5.99	1.19	5.62	.95

Note. Row entries entries with different subscripts differ at $p < 0.05$.
[a]Higher scores indicate greater interference.

Table 29.

Correlations for young adults (lower half-matrix) and older adult (upper half-matrix) outcome measures.

	1.	2.	3.	4.	5.	6.
1. DJG Scale		-.072	.186	-.022	-.189	.080
2. Trails Interference	-.070		.168	.299**	-.182	.288**
3. Stroop Interference	.011	.145		.318**	-.219*	.145
4. Average Cognitive Age	.227*	.163	-.008		-.264**	.086
5. Reading Comprehension	.079	-.133	-.052	.141		-.131
6. Average Reading Time	.134	-.187	.233*	-.044	.200	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Note. Intercorrelations for young adults (*n* = 93) are presented below the diagonal, and intercorrelations for older adults (*n* = 101) are presented above the diagonal.

Effect of primes on young vs. older adults.

The final set of analyses compared young and older adults and participants assigned to the three loneliness priming manipulations (future alone, future belonging, and future misfortune) using a 2 (age group) X 3 (priming conditions) ANOVA for the three outcome measures: Reading comprehension, Stroop Interference, and Trail Making Interference.

Executive Function Tasks. Providing future alone feedback was hypothesized to result in short-term cognitive declines in executive function. Participants in the future alone condition were expected to have more interference on the Stroop and Trail Making tests than participants in the future belonging or future misfortune condition. Further, older adults were predicted to be as vulnerable to this loneliness priming manipulation as young adults. The main effects for age group, F (1, 112) = .03, $\eta^2 < .01$, p = .87, and prime, F (2, 112) = 1.01, η^2 = .02, p = .37, were not significant for Trail Making interference (see Figure 2). For Stroop interference, there was a significant main effect for age group, F (1, 111) = 67.50, η^2 = .39, $p < .01$. Young adults (M = .25, SD = .09) had better inhibitory control on the Stroop test than older adults (M = .42, SD = .12). The main effect of prime, F (2, 111) = .38, η^2 = .01, p = .69, was not significant for Stroop interference (see Figure 3). Neither interaction was significant, Trail Making F (2, 112) = .38, η^2 = .01, p = .68, Stroop F (2, 111) = .04, $\eta^2 < .01$, p = .96.

Figure 2. Mean Trail Making interference scores for young adults and older adults assigned to the 3 priming conditions. Error bars indicate standard deviations.

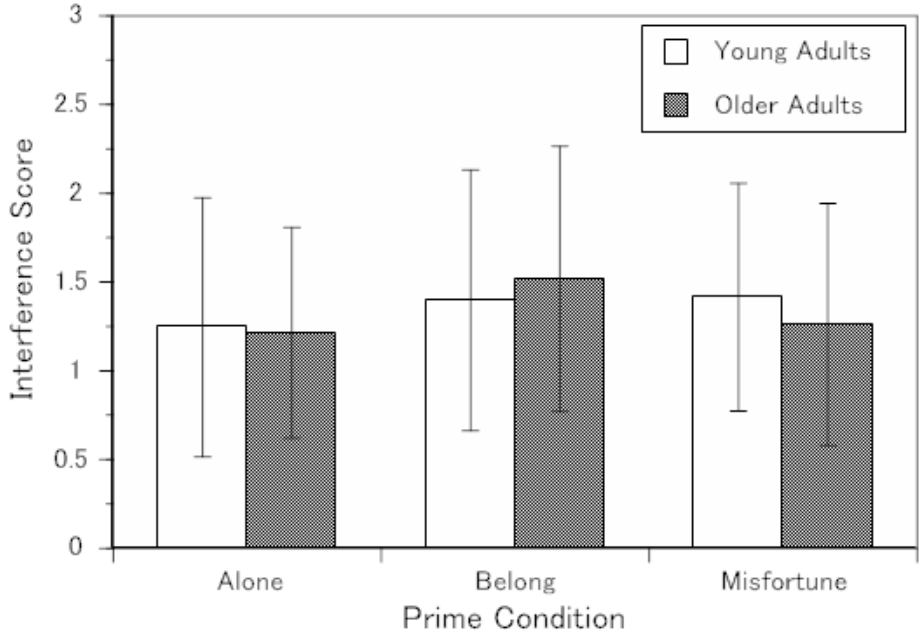
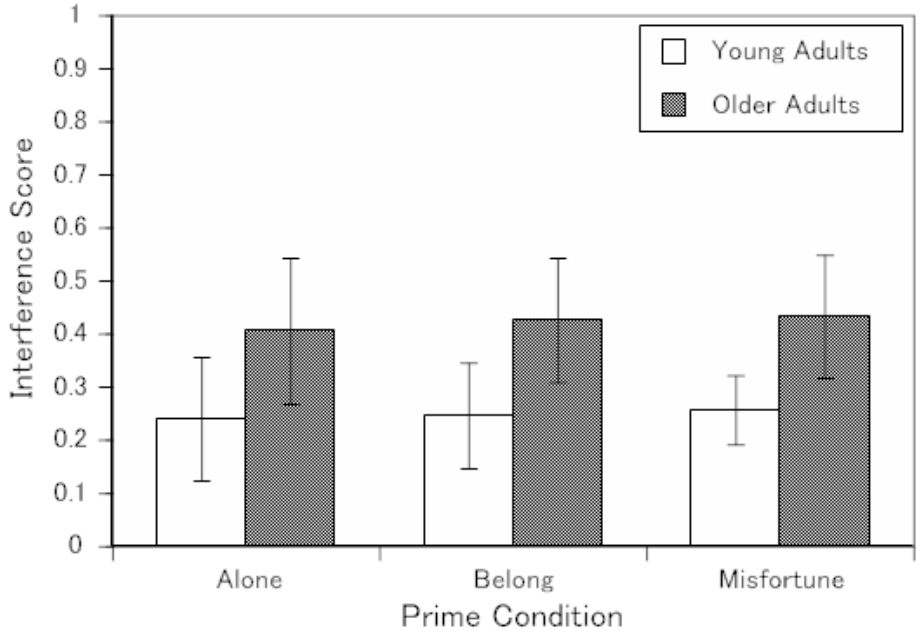


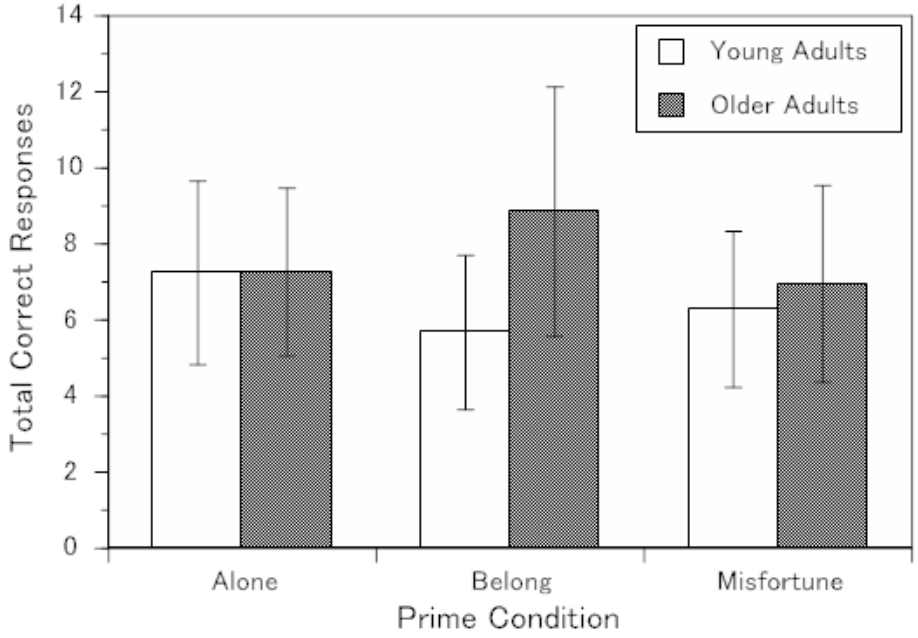
Figure 3. Mean Stroop interference scores for young adults and older adults assigned to the 3 priming conditions. Error bars indicate standard deviations.



Reading Comprehension. Providing future alone feedback was hypothesized to result in short-term cognitive decline on the reading comprehension task. Young adults' results were expected to replicate the findings of Baumeister, Twenge, and Nuss (2002): young adults in the future misfortune condition were predicted to have similar reading comprehension scores as young adults in the future belonging condition; young adults in the future alone condition were predicted to have impaired reading comprehension compared to young adults in the future belonging or future misfortune conditions. Older adults were predicted to be as vulnerable to the priming manipulation as young adults. The main effect for age group, F (1, 112) = 7.58, η^2 = .07, p < .01 was significant; however the main effect of prime, F (2, 112) = .831, η^2 = .02, p = .44, was not significant for reading comprehension. Older adults (M = 7.69, SD = 2.82) had better reading comprehension than young adults (M = 6.38, SD = 2.22). There was a significant interaction, F (2, 112) = 4.20, η^2 = .07, p = .02. Older adults in the belonging prime condition (M = 8.85, SD = 3.28) had significantly better reading comprehension than the young adults in the belonging prime condition (M = 5.67, SD = 2.03), p < .01, whereas reading comprehension scores for young and older adults in the 2 other conditions were similar, p > .05. Further comparisons revealed that reading comprehension scores for young adults in all three prime conditions were equal, both p > .05,

whereas reading comprehension scores for older adults in the belonging condition were significantly greater than those for the older adults in the alone condition, $p = .049$, and significantly greater than those for the older adults in the misfortune condition, $p = .017$. See Figure 4.

Figure 4. Mean reading comprehension scores for young adults and older adults assigned to the 3 priming conditions. Error bars indicate standard deviations.



Cognitive Age. Perceived cognitive age was hypothesized to be sensitive to the effects of the loneliness priming. It was predicted that providing future alone would result in a short-term increase in perceived cognitive age, particularly for older adults. There was a significant main effect for age group, F (1, 112) = 1042.93, $\eta^2 = .91$, $p < .01$. Young adults' perceived cognitive age ($M = 1.56$, $SD = .41$) was lower than older adults' ($M = 5.75$, $SD = .86$), regardless of condition. The main effect for prime, F (2, 112) = .97, $\eta^2 = .02$, $p = .38$, was not significant nor was the interaction, F (2, 112) = .79, $\eta^2 = .02$, $p = .46$. See Figure 5). A cognitive age discrepancy score was also computed by subtracting the perceived age (in decades) from the actual age (in years). A greater discrepancy suggests that participants view themselves as cognitively younger than their actual age. For the discrepancy scores, there was a main effect for age group, F (1, 112) = 104.61, $\eta^2 = .50$, $p < .01$. Young adults' age discrepancy ($M = -3.36$, $SD = 4.07$) was lower than older adults' ($M = -13.40$, $SD = 5.94$), regardless of condition. The main effect for prime, F

(2, 112) = .51, η^2 = .01, p = .60, was not significant nor was the interaction, F (2, 112) = .43, η^2 = .01, p = .65. See Figure 6.

Figure 5. Mean cognitive age of young adults and older adults. Error bars indicate standard deviations.

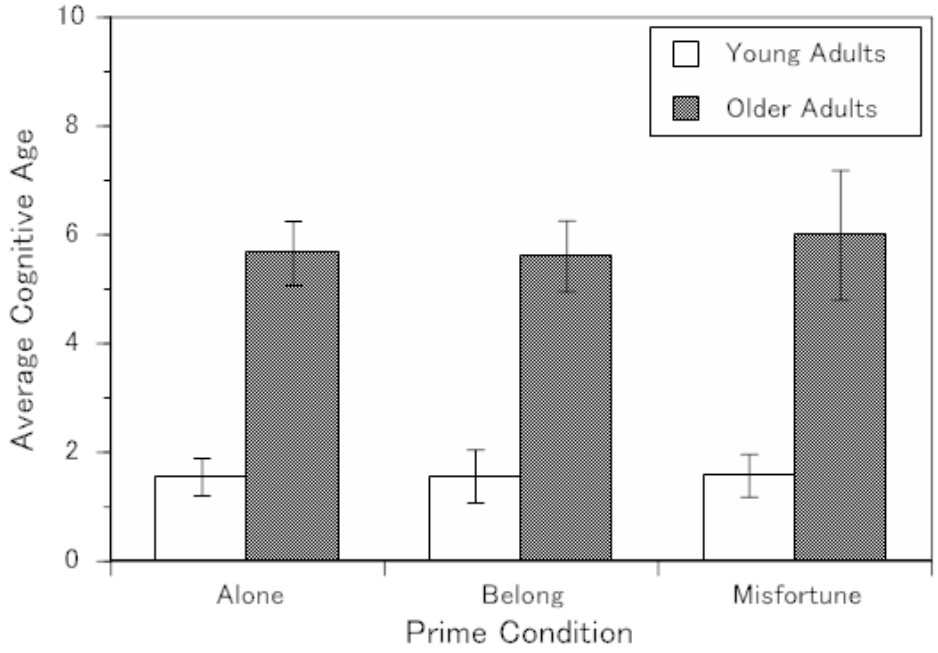
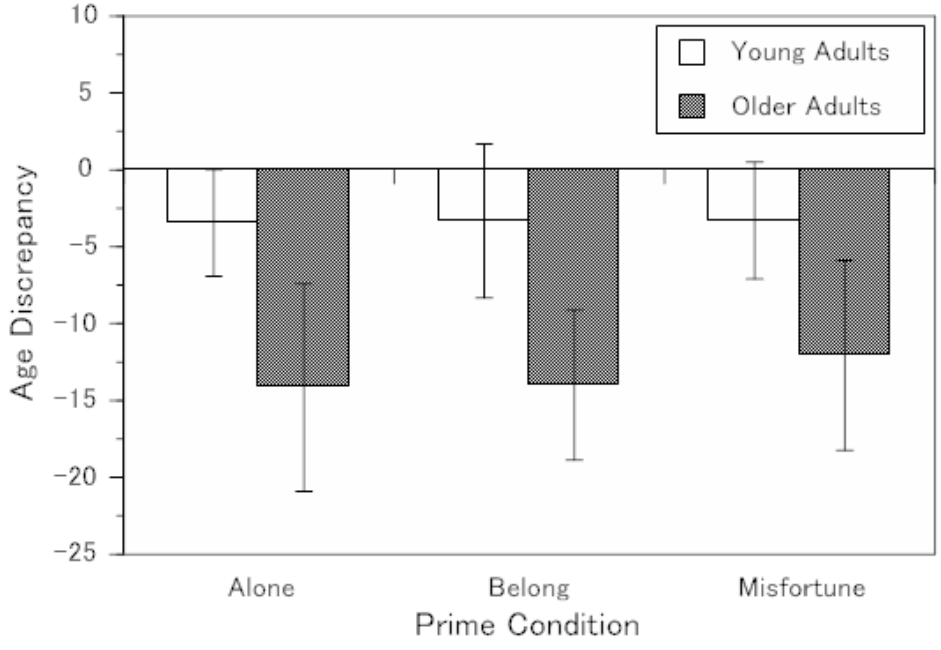


Figure 6. Mean cognitive age discrepancies for young adults and older adults assigned to the 3 priming conditions. Error bars indicate standard deviations. Negative numbers indicate actual age is older than perceived age.



Chapter 5: Discussion

Testing Hypotheses

This dissertation investigated two major questions by experimentally testing the relationship between loneliness and cognition. The first question was whether or not priming loneliness can cause immediate cognitive change in both young adults and older adults. In other words, can priming loneliness result in short-term cognitive decline? The second question examined how loneliness priming affects cognition. It asked is executive function affected by priming loneliness? To answer these questions, young adults and older adults were primed with false feedback about their future to induce state loneliness. They were told they faced a future alone, one in which "relationships don't last." Other participants were told they faced a future in which "relationships will last," a future of belonging; yet others were told they faced a future filled with misfortune in which they "will have accidents." Following these primes, participants were given a series of tests to determine if the primes resulted in short-term changes to cognition.

The first goal of this dissertation was to investigate if it was possible to affect cognition by priming loneliness. Based on previous research by Baumeister, Twenge, and Nuss (2002), young adults were expected to replicate the original pattern of results. Young adults in the "future alone" prime were hypothesized to perform significantly worse on a reading comprehension test than young adults in the "future belonging" or "future misfortune" conditions; those in the "future belonging" and "future misfortune" condition were expected to have similar performance on the reading comprehension test . Of interest was determining whether older adults would show a similar pattern. The results indicated that the priming manipulation did not affect reading comprehension by either young adults or older adults. This study failed to replicate the findings of Baumeister and colleagues (2002) that young adults' reading comprehension was impaired by inducing a short-term sense of loneliness as a result of the "future alone" priming. Possible explanations for this failure to replicate Baumeister et al. will be considered below.

The second goal of the dissertation was to include other measures of cognition than reading comprehension. Baumeister et al. (2002) suggested that loneliness affects self-regulation or executive

function. To directly test this account, two executive functions tests, the Trail Making Task and the Stroop Test, were administered to all participants. However, interference scores, commonly used to measure the executive function did not differ as a result of the loneliness priming. Again, these results fail to replicate the original findings that short-term cognitive changes can be induced by priming loneliness.

The original motivation for examining whether priming loneliness can result in short-term cognitive declines was to provide an explanation for research findings linking loneliness to cognitive decline in older adults. Impairments of executive function have been linked to a wide range of other age-associated impairments, including impairments of daily activities. Older women, those widowed, divorced, or never married, and those who are socially isolated may experience chronic cognitive impairments as a result of loneliness on executive function. The present findings provide limited support for this hypothesis. Older men were lonelier than older women, and young adults and older adults showed similar patterns of loneliness. When comparing lonely and non-lonely participants' performance, lonely and non-lonely young adults did not differ on cognitive measures while lonely older adults had significantly slower processing speed than non-lonely older adults. More severe loneliness was associated with being male. Although loneliness severity was associated with slower processing speed, this was exclusively for older adults. However, no effects of priming loneliness on cognition were observed: non-lonely adults who were told they faced a future alone did not perform more poorly on the reading comprehension or executive function test compared to non-lonely adults primed with a future of belonging or a future of misfortune.

"Failure to Replicate" Considerations

A number of possible explanations may account for the failure to replicate the original Baumeister et al. finding (2002): controlling for loneliness; adapting the primes; providing time for reflection; the believability of the primes; and priming of age stereotypes, not loneliness.

1. Baumeister et al. (2002) tested young adults recruited from an introductory psychology course; the participants are described as 63% male, 72% White, and average age was 19.2 years. None were screened for loneliness. In this dissertation, a loneliness scale was administered to all participants at the

beginning of the experiment to assess baseline loneliness. On the basis of this assessment, lonely people were identified and excluded from the loneliness priming manipulation. This was done to avoid possible emotional distress due to the priming manipulation on participants who were already in a compromised emotional state. The participants who received the priming manipulation were all non-lonely individuals, as defined by scores of 2 or less on the de Jong Gierveld loneliness scale. Thus it is possible that the reading comprehension differences reported by Baumeister et al. were caused by preexisting, unmeasured differences in loneliness, rather than by feelings of loneliness induced by the future alone prime.

2. The primes used in the dissertation were adapted from the originals used by Baumeister et al. (2002). Those primes were written for young adults; they referred to relationships "lasting (or not lasting) into your later years," having "a long and stable marriage and friendships," "breaking an arm or leg a few times." The primes were adapted for use with both young and older adults; hence, they referred to "close relationships…not continuing for your entire life," maintaining long, stable relationships," and "more likely to experience falls or injuries." In particular, the original "future alone" prime included specific references to future ages, such as 20s and 30s. It also included references to romantic relationships and failed marriages; the adapted primes did not refer to specific ages or marriage relationships. The original primes are included in Appendix E and the adapted primes can be found on page 37. Additionally, the original primes were more variable in length than the primes in the current study. The original "future alone" prime is almost double the number of words as the original "future belonging" prime ($words_{FA}$ = 70, $words_{FB}$ = 40, respectively). It is possible the changes to the primes resulted in a significant reduction of manipulation effectiveness. The longer, more detailed "future alone" primes used in the original study may have had a greater impact than than "future belonging" or "future misfortune" primes used in that study or than the more generic "future alone" primes used in the dissertation.

3. Baumeister et al. (2002) assessed reading comprehension following an easy non-demanding "short filler task of rating pictures of nature scenes." This dissertation replaced the picture rating task with the executive function measures, Part B of the Trail Making test and the Stroop Colors test. This substitution may have reduced the effect of the loneliness prime on reading comprehension. The

executive function tasks were more cognitively demanding than the rating task. The low demand filler task used by Baumeiser et al. may have enabled the participants to consider the primes in greater depth, allowing participants to ruminate on their future of being alone. Because they were engaged in the demanding executive function tasks, participants in this dissertation may not have been able to think about their futures, thus reducing the effect of the prime on cognition.

4. Baumeister et al. (2002) did not directly test the believability of the future priming information. In this dissertation, a series of probe questions was administered to all participants at the end of the experiment to assess whether or not they believed the false feedback. Believability was high: although only 44% believed the "future alone" prime, 97% believed the "future belonging" prime and 56% believed the future misfortune prime. However, the doubters and believers did not differ on comparisons of demographics, personality traits or baseline cognitive measures and there was no indication that believers were more affected by the primes than the doubters. Therefore prime believability does not provide an adequate explanation for the failure to replicate the Baumeister et al. findings. However, it is possible participants were responding to demand characteristics or experimenter expectancy effects and thought they "should" believe the primes. Participants may have withheld their doubts about the primes leading to an overestimation of believers.

5. The "future alone" primes may have primed negative age stereotypes, rather than inducing state loneliness. Self-stereotyping makes it more likely that "behavior consistent with the stereotype will occur" (O'Brien & Hummert, 2006). The assimilation of behavior to the group stereotype is more likely to occur in the stereotyped group. These observations suggest that the loneliness primes might have been much more impactful on the older adults than the young adults. Reminding participants that "people of your age" experience these negative outcomes could have resulted in increased self-stereotyping, making them feel older as well as causing them to adjust their performance to conform to the stereotype (O'Brien & Hummert, 2006). In this dissertation, participants were asked questions to assess their perception of their own cognitive age. However, young adults in all three prime conditions reported similar cognitive ages as did older adults, suggesting that the primes did not differentially affect participants' self-

perceptions. Note that non-lonely young adults reported younger cognitive ages than lonely young adults, suggesting that the measure may be sensitive to loneliness for that age group. Older adults did have larger discrepancies between their actual and perceived ages; their discrepancies were negative which indicated that older adults felt younger than their actual age. This might indicate that the sample of older adults was particularly resilient to the loneliness priming.

"Executive Function" Considerations

The failure to find effects of the prime conditions on the executive function measures may be due to the selection and administration of the tests, or their sensitivity to the effect of loneliness. Trail Making and Stroop are widely used, well-researched cognitive measures of executive function. There was a clear age difference between young adult and older adult performance on Trails A and Stroop XXXs; the two speed measures were correlated in both young and older adults. Additionally, increased severity of loneliness was correlated with slowed processing speed for older adults. The interference scores for young and older adults did not differ on the Trail Making interference, t (189) = -.10, p = .924, but differed significantly on the Stroop Task interference; t (188) = -11.52, $p < .01$; interference scores for Trail Making and Stroop were not intercorrelated for young adults or for older adults. And loneliness was not correlated with either interference score: Trail Making, (r_{ya} (93) = -.07, p = .50; r_{oa} (98) = -.07, p = .48) or Stroop Task (r_{ya} (91) = .01, p = .92; r_{oa} (93) = .19, p = .07). Typically, the two parts of the Trail Making and Stroop tests are presented sequentially or back- to- back in cognitive batteries. May, Hasher, and Kane (1999) suggested that inhibition builds up over the course of administrating executive function tests, and builds up more rapidly for older than young adults. This build-up of inhibition results in poor performance on the 2nd part of the Trail Making and Stroop tests, resulting in greater interference for older than young adults. It is possible that separating the 2 parts of these tests while completing the reading span test and the passage reading task may have allowed this inhibition to dissipate, perhaps more rapidly for older than young adults, more rapidly for for more lonely than less lonely adults, or more rapidly for one test than for the other (also see Bowles & Salthouse, 2003). Thus, the research design may

have contributed to the failure to confirm prior finds of age differences in Trail Making and Stroop interference, reduced the covariance between the 2 tests, or blocked any effect of loneliness on either test.

Limited research has been conducted on the specific relationship between loneliness and executive function. Although the two executive function tasks, Trail Making and Stroop, have been shown to be sensitive to the effects of aging and neurodegenerative disorders (Bélanger, Belleville, & Gauthier, 2010; May & Hasher, 1998; McDowd, et al., 2011; Muslimovi, Post, Speelman, & Schmand, 2005; Salthouse, et al., 2003), the connection between these tasks and trait or state loneliness has not been established. Cacioppo and Hawkley, (2009) referenced two studies. The first study was the foundation for this dissertation: they cited the Baumeister, Twenge, and Nuss (2002) paper as compelling evidence that loneliness is directly related to poor executive functioning. However, this dissertation failed to replicate those findings. The second cited study (Shintel et al., 2006) found lonely participants experienced greater interference on the emotional Stroop compared to the non-lonely participants when presented with negative social words. The lonely participants showed smaller, similar interference patterns to non-lonely participants when completing the task with positive social words. The emotional Stroop task contrasts naming the color of blocks of XXXs with naming the colors of negative words such as “sadistic,” “mean,” or “hostile” or positive words such as “kind,” “sincere,” or “talented.” The classic Stroop task used in this dissertation did not find increased interference for lonely participants or for those participants in the “future alone” prime condition.

Most studies investigating loneliness and cognition do not focus on executive function; they typically assess general measures of cognition like the Mini-Mental Status Examination (MMSE) (Conroy, Golden, Jeffares, O'Neill, & McGee, 2010; Green, Rebok, & Lyketsos, 2008; Hotlzman et al., 2004; Shankar, Hamer, McMunn and Steptoe, 2013) and memory (O’Luanaigh et al., 2012; Seeman, Lusignolo, Albert, & Berkman, 2001). While a large body of research connects loneliness and cognition, it does not specifically point to executive function as the source of the linkage in older adults.

Other Considerations

In addition to the priming manipulation and the executive functioning considerations, this dissertation found surprising results that warrant expanded discussion. Contrary to expectations, this sample of healthy young adults and older adults reported a relatively high rate of loneliness compared to large population surveys. At the core of this issue is the measurement of loneliness. However, loneliness patterns were similar for young adults and older adults which may shed light on why older adults appeared to benefit from the future belonging priming manipulation.

1. Overall, 43% of the young adults and 42% of the older adults who were tested in this dissertation were classified as lonely based on the de Jong Gierveld loneliness scale. While multiple studies report 10 - 15% of large samples are lonely (Hawthorne, 2008; O'Laughlin et al., 2012; Victor et al., 2000), there have been occasional findings that 40% of older adults are lonely (Weeks, 1994). The de Jong Gierveld loneliness scale was developed by Dutch researchers (De Jong Gierveld & Kamphuis, 1985). Although the scale has been used with both young adults and older adults (Buunk & Prins, 1998; de Jong Gierveld & Van Tilburg, 2006; van Tilburg, Havens, & de Jong Gierveld, 2004), norming and validation studies were done primarily using older adult Dutch samples (Van Tilburg & De Leeuru, 1991).

De Jong Gierveld and Tesch-Romer (2012) reported that cultural differences between Eastern and Western European countries resulted in higher average loneliness scores for Eastern European participants. They go on to suggest that cultural differences at the individual level (e.g. perceived discrepancy between relationships a person has and relationships a person wants) and at the societal level (e.g. cultural norms for living arrangements or demographic composition of the country) may both influence the experience of loneliness (de Jong Gierveld & Tesch-Romer, 2012). In addition, the Likert scale could have also presented problems; one of the choices was "more or less." "More or less" responses were automatically coded in favor of the lonely response potentially inflating the loneliness scores. Some studies opt to adjust the scale choices to more traditional "agree" to "disagree" (Buunk & Prins, 1998); changes in scale language may result in subtle response differences from participants.

The de Jong Gierveld cut-offs (van Tilburg & de Jong Gierveld, 1999) may be too sensitive to other potential confounding variables such as depression or social isolation. They based the cutoff scores on the individuals' perceptions of their own loneliness in a large sample of Dutch older adults (n = 3,823; 54-89 years old). In their manual, de Jong Gierveld and van Tilburg (1999) note that the cutoffs were relatively untested and cultural bias may have affected the severity cutoffs. In retrospect, a single item such as "Do you feel lonely?" item or a second scale (e.g. the UCLA loneliness scale) could have been used to corroborate the DJG Loneliness Scale classification of lonely vs. non-lonely individuals. Measures of depression, social isolation and social network size would have provided additional insight as to why so many participants were classified as lonely.

2. This dissertation hypothesized that young adults and older adults would be similarly susceptible to cognitive changes from the priming manipulation; all participants were expected to experience a decline in reading comprehension and increase in interference when presented with the "future alone" prime. However, the results found that neither young adults' nor older adults' cognition was changed by the negative "future alone" prime. In retrospect, older adults may be protected from feeling lonely after the "future alone" prime based on the findings of the Socioemotional Selectivity Theory (Carstensen, 2006).

The loneliness priming technique of Baumeister et al. (2002) relies on the manipulation of "future time" by providing misleading information about the likelihood that the individual will have good vs. poor social relationships in the future. Older adults may not be as susceptible as young adults to this manipulation because they may not have the same sense of 'future time." Socioemotional Selectivity Theory (SST) suggests that as people age, their sense of "future time" or "time horizons" condense. As their sense of a limitless future diminishes, motivations shift from knowledge-based goals to emotion regulation-based goals (Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999). For example, Carstensen (2006) reports that older adults remember emotionally positive information better than emotionally negative information and spend less time gathering information from their environment, reflecting this shift to emotion regulation, away from information gathering.

This shift to emotion regulation may have combined with the false priming information in an unexpected way. By telling the older adults in the 'future belonging' condition that they could expect to be part of strong, healthy relationships and have people that will care about them for their whole life, the primes may have enhanced their self-esteem or sense of self-efficacy, benefiting their performance on the reading comprehension test.

Older adults in the "future belonging" prime might have also benefited from self-stereotyping. Levy (1996) found that young adults were not affected by stereotype priming; however, older adults were affected by both positive and negative primes. The positive primes boosted memory and the negative primes impaired older adults' memory. She suggested that young adults are buffered from stereotypes, possibly by the belief that they are "immune" from memory loss whereas older adults are especially sensitive to suggestions they have (exceptionally) good memory. In the same way, the young adults in the current dissertation may have disregarded all primes as not applicable to themselves, while older adults benefitted from the exposure to the positive "future belonging" prime.

General Conclusions and Future Directions

Although this dissertation failed to replicate the findings of Baumeister et al. study (2002), there were a number of possible factors that could account for the outcomes based on the experimental design, the primes, the loneliness measure, and the way cognitive and executive functions were tested. The findings of this research also fail to corroborate previous research on loneliness with regards to the classic risk factors. The expected relationships between the loneliness and cognitive or demographic variables did not emerge. The most interesting finding is that older adults experienced a reading comprehension boost when they were presented with the "future belonging" prime. However, without a non-lonely no prime control, it is not possible to determine how "future belonging" participants compared to other non-lonely people. Perhaps the negative primes were reducing performance on the reading comprehension task while the positive prime maintained the individuals' normal performance.

This dissertation focused on the relationship between cognition and loneliness in young versus older adults. However, the findings of the research suggest that foundational research about the nature of

loneliness remains unstudied. First and foremost, loneliness measures need continued refinement to assure appropriate sensitivity and validity across age groups and cultural contexts. Currently, despite the existence of a number of loneliness scales (e.g. de Jong Gierveld and UCLA loneliness scales) a short measure capable of providing useful, well-tested cutoffs for loneliness is not available. Secondly, the relationship between loneliness and cognition may be different for young adults and older adults. For older adults, the experience of loneliness may not be the central factor influencing cognitive decline; perhaps other correlated variables such as depression and social isolation are critical. Finally, if priming with the "future belonging" manipulation does boost cognitive performance, this technique might be a potential avenue for alleviating the negative outcomes of loneliness thus improving the long term cognition and overall wellbeing of adults at any age. Thus, the conclusion to be drawn from this study is that despite the extensive loneliness and social isolation literature, the short term impacts of loneliness on cognitive function are not yet well understood and continued experimental research is warranted.

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Appendix A. Summary of all tests and procedures.

	Tests and Procedures	Outcome Measures
1	Informed Consent	
2	Random assignment to loneliness manipulation: Future Alone, Future Belonging, or Future Misfortune	
3	Demographic Information	
4	De Jong Gierveld Loneliness Scale	Loneliness score: those scoring 3+ are excluded from manipulation prime
5	Ten Item Personality Inventory	Extraversion Score
6	Shipley Vocabulary Test	Vocabulary Score
7	Executive Function Measures (Part 1): Trail A and Stroop X Color Vision Screening	Time to complete Trails A and Stroop XXX correctly named Color Vision
8	Reading Span	Reading Span total
9	Reading Passages	Reading Rate
10	Personality and Priming Feedback (according to random assignment)	
11	Executive Function Measures (Part 2): Trail B, Stroop Colors	Time to complete Trails B, Stroop Colors correctly named
12	Reading Comprehension	Percent Correct Responses
13	Cognitive Age	Average of cognitive age responses
14	Probe Questions and Debriefing	Audio Recorded

Appendix B. Consents, Probe Questions and Debriefing Scripts.

Oral Consent Script

Hi, thanks for coming in today. My name is _____and I'm a researcher in this lab. We're doing a study that will require us to collect measures of your personality, reading ability, and executive function. Executive function includes mental abilities like memory and our ability to inhibit our responses to irrelevant information in the environment. To better understand the connections between these variables, we will ask you to complete some questionnaires, cognitive measures and a reading task.

Before we get started on the tasks, I want to mention a few things about your participation in this study. First of all, any answer you give to a question will be stored anonymously. In other words, all of your responses on all of the measures will be completely confidential, and will never be associated with you. What that means for you is that throughout the study you should feel free to respond to all of the questions in a way as accurately as possible for you personally. The questions about you have no "right" or "wrong" answers. So rather than spending too long on those questions, or thinking about how you "ought" to respond, just answer with your first response, okay? If at any point you would like to discontinue your participation, you can let me know. There is no penalty for discontinuation. So, if there aren't any initial questions, I'll have you take a look at this consent form.

INFORMED CONSENT STATEMENT FOR PAYMENT

Executive Function in Young and Older Adults

INTRODUCTION

The Department of Psychology at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or the University of Kansas. You must be at least 18 years old to participate in this study.

PURPOSE OF THE STUDY

We are interested in collecting personality, cognitive measures that test executive function, and reading measures from young and older adults. After completing the study, you will receive more detailed information regarding the nature of the study.

PROCEDURES

We will give you some questions about your background, your personality, and cognitive tasks to measure speed of processing and memory. Then you will read two passages. After reading the passages, we will give you feedback about your personality score and ask you to complete some additional cognitive measures. Then we will give you comprehension questions to test your memory of the passages you read. Finally, we will audio record your responses to the some questions about the study experience. The study should take about 1 hour to complete. All of the collected data and audio files will only be reviewed by the researchers and will be stored in locked drawers and password guarded computers separated from any identifying information.

RISKS

There is minimal risk associated with this research. You should not experience any stress or discomfort beyond what you might experience in your normal everyday life.

BENEFITS

There are no direct benefits to you for participating. However, your participation will hopefully increase our understanding of executive function and differences between young and older adults.

PAYMENT TO PARTICIPANTS

You will be paid a $10.00 per hour honorarium for your time and participation. This will be paid at the end of your participation. We need to ask you for your social security number in order to comply with federal and state tax and accounting regulations.

PARTICIPANT CONFIDENTIALITY

Your name will not be associated in any way with the information collected about you or with the research findings from this study. The researcher(s) will use a study number instead of your name. The researchers will not share information about you unless required by law or unless you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your unidentified information for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose information collected about you, in writing, at any time, by sending your written request to: Ellen Rozek, Fraser Hall, 1415 Jayhawk Blvd., Lawrence, Kansas 66045. If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 864-7429 or (785) 864-7385, write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

_____ _____
Type/Print Participant's Name Date

_____
Participant's Signature

Researcher Contact Information

Ellen Rozek
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INFORMED CONSENT STATEMENT FOR RESEARCH CREDIT

Executive Function in Young and Older Adults

INTRODUCTION

The Department of Psychology at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or the University of Kansas. You must be at least 18 years old to participate in this study.

PURPOSE OF THE STUDY

We are interested in collecting personality, cognitive measures that test executive function, and reading measures from young and older adults. After completing the study, you will receive more detailed information regarding the nature of the study.

PROCEDURES

We will give you some questions about your background, your personality, and cognitive tasks to measure speed of processing and memory. Then you will read two passages. After reading the passages, we will give you feedback about your personality score and ask you to complete some additional cognitive measures. Then we will give you comprehension questions to test your memory of the passages you read. Finally, we will audio record your responses to the some questions about the study experience. The study should take about 1 hour to complete. All of the collected data and audio files will only be reviewed by the researchers and will be stored in locked drawers and password guarded computers separated from any identifying information.

RISKS

There is minimal risk associated with this research. You should not experience any stress or discomfort beyond what you might experience in your normal everyday life.

BENEFITS

There are no direct benefits to you for participating. However, your participation will hopefully increase our understanding of executive function and differences between young and older adults.

PARTICIPATION CREDIT

You will receive credits based on the SONA policy by the Psychology Department. You will receive 1 credit for every 30 minutes of participation. This will be updated on your personal SONA account at the end of your participation within specified time. This study will take approximately 1 hour or 2 credits.

PARTICIPANT CONFIDENTIALITY

Your name will not be associated in any way with the information collected about you or with the research findings from this study. The researcher(s) will use a study number instead of your name. The researchers will not share information about you unless required by law or unless you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your unidentified information for purposes of this study at any time in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, you cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to participate in this study at any time. You also have the right to cancel your permission to use and disclose information collected about you, in writing, at any time, by sending your written request to: Ellen Rozek, Fraser Hall, 1415 Jayhawk Blvd., Lawrence, Kansas 66045. If you cancel permission to use your information, the researchers will stop collecting additional information about you. However, the research team may use and disclose information that was gathered before they received your cancellation, as described above.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 864-7429 or (785) 864-7385, write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

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Type/Print Participant's Name Date

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Participant's Signature

Researcher Contact Information

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Probe Questions

1) *Did you have any general thoughts on the experiment?*
2) *Have you participated in experiments like this before? If so, what were they like?*
3) *Were all the instructions pretty clear throughout the study?*
4) *Let's talk about the part of the study when you were given feedback about your personality and your future. Did anything about that strike you as interesting or unusual?*
5) *Do you feel like any of your responses on any of the tasks you did today might have affected your responses on any of the other tasks?*
6) *Alright, finally, sometimes when we do these studies, the participants feel like there might be a bit more going on than we told them about in the beginning. Did you feel that way at any time during this particular study?*

Verbal Debriefing

The reason I've been asking you all these questions is there was indeed a bit more going on here than I told you about in the beginning. So what I'd like to do now is give you an idea of the theory behind our research, and let you know exactly what you were doing here today.

Research shows that loneliness is a common human experience that can impact many aspects of people's lives. For example, people who are lonely may experience depression or have poor quality sleep. Feeling lonely might also have a short term impact on cognitive function, or the way our minds work on some tasks. That is the idea we are testing in today's study. Although we gave you accurate feedback about your extraversion score from the personality test, the feedback about your future was made up as a way to temporarily change people's feelings about their loneliness.

We provided some participants with false feedback about having lots of friends; some participants got false feedback about being alone a lot; some participants got false feedback about becoming accident-prone. ***There is no way for us to predict your future****. The feedback about your future was determined on a completely random basis before you arrived. If you were really lonely based on the test you completed, we would not have done this – after all, we would not have wanted to make lonely people feel any worse. So only people who "pass" the loneliness test get this sort of feedback about their future.*

Some have claimed that feeling lonely can temporarily interfere with cognitive abilities. So we wanted to find out if we can make people feel lonely, by telling them they are going to "end up alone" in the future, and then if this would lead to difficulty answering questions about the passages and difficulty on two other tasks. We tell some people they are going have many meaningful relations in the future or others are told they will have many accidents in the future. These "futures" should not make people feel lonely and so they should not have difficulty on the questions about the passages and other tasks. Again, we make these predictions based on the idea that feeling lonely can temporarily interfere with your normal cognitive abilities.

The reason I didn't tell you these details in the beginning of the experiment was that we needed to create situation in which you would temporarily believe the false information we were giving you about your future. If you'd known all along what the purpose of our study was, and that some of the materials were fabricated, you probably wouldn't have responded naturally and given us your honest opinions. Again, the feedback we gave you about your future is made up. We don't know if you will have many or few friends in the future or if you will be accident prone. The information we gave you about being extroverted or introverted was accurate, based on your responses to the questions about the personality traits like enthusiasm and quiet. But that doesn't have any bearing on whether or not you are going to be lonely in the future. Both extraverts and introverts can be lonely but we can't predict your future. I want to make sure that you understand why we didn't tell you this information up front, and I also want to make sure that you feel okay.

One more very important point before I let you go: hopefully it's obvious that we've invested a lot of work into this research, and we take it very seriously, and as I mentioned, if you came in here knowing what the experiment was about then your responses would be skewed and our results wouldn't be interpretable at all and everyone would have wasted a lot of time and resources. In other words, it is very important that you don't mention that actual purpose of the study to other potential participants. It's critical that people don't know about the experiment when they come in. Can I get your word that you won't tell anyone what we were really looking at in this experiment? Thanks: if someone is interested in what the experiment is about, please don't tell them everything I just told you; feel free to tell them simply that we do research on the executive functions of young and older adults. Do you have any questions? Alright, thanks again for your participation.

Appendix C. Demographic information and response alternatives.

Participant Characteristic	Response Alternatives
Age	Number of years old
Gender	Male
	Female
Race/Ethnicity[a]	Hispanic
	African American
	Asian or Pacific Islander
	Native American
	Caucasian
	Other
Education	Not high school graduate
	High school graduate (including equivalency)
	Some college or associate degree
	Bachelor's degree
	Master's degree
	Doctoral degree or terminal professional degree
Occupation/ Former Occupation	Officials and Managers
	Professionals
	Technicians
	Sales Workers
	Administrative Support Workers
	Craft Workers
	Operatives
	Laborers and Helpers
	Service Workers
	Students
Marital Status	Single, never married
	Married
	Divorced
	Widowed
	Remarried
	Committed Relationship
Living Situation[a]	Living alone
	Living with roommate(s)
	Living with spouse/partner
	Living with dependent children (under 18)
	Living with family (adults children, parents, extended family)
	Living in a group situation (dorm, retirement community)

[a]Participants can select more than one option if appropriate.

Appendix D. Reading Comprehension Passages Adapted from Mathur, H. SAT Reading Comprehension, In *Practice SAT Reading Comprehension Tests.* Retrieved August 30, 2012, from http://www.majortests.com/sat/reading-comprehension.php.

The Social Function of Science

The pioneers of the teaching of science imagined that its introduction into education would remove the conventionality, artificiality, and backward-lookingness which were characteristic of classical studies, but they were gravely disappointed. So too in their time had the humanists thought that the study of the classical authors in the original would banish at once the dull pedantry and superstition of mediaeval scholasticism. The professional schoolmaster was a match for both of them, and has almost managed to make the understanding of chemical reactions as dull and as dogmatic an affair as the reading of Virgil's Aeneid.

The chief claim for the use of science in education is that it teaches a child something about the actual universe in which he is living, in making him acquainted with the results of scientific discovery, and at the same time teaches him how to think logically and inductively by studying scientific method. A certain limited success has been reached in the first of these aims, but practically none at all in the second. Those privileged members of the community who have been through a secondary or public school education may be expected to know something about the elementary physics and chemistry of a hundred years ago, but they probably know hardly more than any bright boy can pick up from an interest in wireless or scientific hobbies out of school hours.

As to the learning of scientific method, the whole thing is palpably a farce. Actually, for the convenience of teachers and the requirements of the examination system, it is necessary that the pupils not only do not learn scientific method but learn precisely the reverse, that is, to believe exactly what they are told and to reproduce it when asked, whether it seems nonsense to them or not. The way in which educated people respond to such quackeries as spiritualism or astrology, not to say more dangerous ones such as racial theories or currency myths, shows that fifty years of education in the method of science in Britain or Germany has produced no visible effect

whatever. The only way of learning the method of science is the long and bitter way of personal experience, and, until the educational or social systems are altered to make this possible, the best we can expect is the production of a minority of people who are able to acquire some of the techniques of science and a still smaller minority who are able to use and develop them.

Adapted from: *The Social Function of Science*, John D Bernal (1939)

1. The author of *Function of Science* implies that the 'professional schoolmaster' has

a. no interest in teaching science
b. thwarted attempts to enliven education
c. aided true learning
d. been a pioneer in both science and humanities.

2. *Function of Science* author's attitude to secondary and public school education in the sciences is

a. ambivalent
b. neutral
c. satirical
d. contemptuous

3. The word 'palpably' in *Function of Science* most nearly means

a. empirically
b. obviously
c. tentatively
d. ridiculously

4. The author of *Function of Science* blames all of the following for the failure to impart scientific method through the education system except

a. poor teaching
b. examination methods
c. the social and education systems
d. lack of interest on the part of students

5. If the author of *Function of Science* were to study current education in science to see how things have changed since he wrote the piece, he would probably be most interested in the answer to which of the following questions?

a. Do students know more about the world about them?
b. Do students spend more time in laboratories?
c. Can students apply their knowledge logically?
d. Have textbooks improved?

6. Astrology is mentioned in *Function of Science* as an example of

a. a science that needs to be better understood
b. a belief which no educated people hold
c. something unsupportable to those who have absorbed the methods of science
d. the gravest danger to society

7. All of the following can be inferred from *The Social Function of Science* passage except

a. at the time of writing, not all children received a secondary school education
b. science teaching has imparted some knowledge of facts to some children
c. the author believes that many teachers are authoritarian
d. it is relatively easy to learn scientific method.

Voyage of the Beagle

That large animals require a luxuriant vegetation has been a general assumption which has passed from one work to another; but I do not hesitate to say that it is completely false, and that it has vitiated the reasoning of geologists on some points of great interest in the ancient history of the world. The prejudice has probably been derived from India, and the Indian islands, where troops of elephants, noble forests, and impenetrable jungles, are associated together in everyone's mind. If, however, we refer to any work of travels through the southern parts of Africa, we shall find allusions in almost every page either to the desert character of the country, or to the numbers of large animals inhabiting it. The same thing is rendered evident by the many engravings which have been published of various parts of the interior.

Dr. Andrew Smith, who has lately succeeded in passing the Tropic of Capricorn, informs me that, taking into consideration the whole of the southern part of Africa, there can be no doubt of its being a sterile country. On the southern coasts there are some fine forests, but with these exceptions, the traveler may pass for days together through open plains, covered by a poor and scanty vegetation. Now, if we look to the animals inhabiting these wide plains, we shall find their numbers extraordinarily great, and their bulk immense. We must enumerate the elephant, three species of rhinoceros, the hippopotamus, the giraffe, the bos caffer, two zebras, two gnus, and several antelopes even larger than these latter animals. It may be supposed that although the species are numerous, the individuals of each kind are few.

By the kindness of Dr. Smith, I am enabled to show that the case is very different. He informs me, that in lat. 24', in one day's march with the bullock-wagons, he saw, without wandering to any great distance on either side, between one hundred and one hundred and fifty rhinoceroses - the same day he saw several herds of giraffes, amounting together to nearly a hundred. At the distance of a little more than one hour's march from their place of encampment on the previous night, his party actually killed at one spot eight hippopotamuses, and saw many more. In this same river there were likewise crocodiles. Of course it was a case quite

extraordinary, to see so many great animals crowded together, but it evidently proves that they must exist in great numbers. Dr. Smith describes the country passed through that day, as 'being thinly covered with grass, and bushes about four feet high, and still more thinly with mimosa-trees.'

Besides these large animals, every one the least acquainted with the natural history of the Cape, has read of the herds of antelopes, which can be compared only with the flocks of migratory birds. The numbers indeed of the lion, panther, and hyena, and the multitude of birds of prey, plainly speak of the abundance of the smaller quadrupeds: one evening seven lions were counted at the same time prowling round Dr. Smith's encampment. As this able naturalist remarked to me, the carnage each day in Southern Africa must indeed he terrific! I confess it is truly surprising how such a number of animals can find support in a country producing so little food. The larger quadrupeds no doubt roam over wide tracts in search of it; and their food chiefly consists of underwood, which probably contains much nutriment in a small bulk. Dr. Smith also informs me that the vegetation has a rapid growth; no sooner is a part consumed, than its place is supplied by a fresh stock. There can be no doubt, however, that our ideas respecting the apparent amount of food necessary for the support of large quadrupeds are much exaggerated.

The belief that where large quadrupeds exist, the vegetation must necessarily be luxuriant, is the more remarkable, because the converse is far from true. Mr. Burchell observed to me that when entering Brazil, nothing struck him more forcibly than the splendor of the South American vegetation contrasted with that of South Africa, together with the absence of all large quadrupeds. In his Travels, he has suggested that the comparison of the respective weights (if there were sufficient data) of an equal number of the largest herbivorous quadrupeds of each country would be extremely curious. If we take on the one side, the elephants, hippopotamus, giraffe, bos caffer, elan, five species of rhinoceros; and on the American side, two tapirs, the guanaco, three deer, the vicuna, peccari, capybara (after which we must choose from the monkeys to complete the number), and then place these two groups alongside each other it is not easy to conceive ranks

more disproportionate in size. After the above facts, we are compelled to conclude, against anterior probability, that among the mamalia there exists no close relation between the bulk of the species, and the quantity of the vegetation, in the countries which they inhabit.

Adapted from: *Voyage of the Beagle*, Charles Darwin (1890)

1. Darwin, the author of *The Voyage of the Beagle*, is primarily concerned with

a. discussing the relationship between the size of mammals and the nature of vegetation in their habitats
b. contrasting ecological conditions in India and Africa
c. proving the large animals do not require much food
d. describing the size of animals in various parts of the world

2. The word 'vitiated' in *The Voyage of the Beagle* most nearly means

a. infiltrated
b. occupied
c. impaired
d. invigorated

3. The flocks of migratory birds are mentioned in *The Voyage of the Beagle* to

a. describe an aspect of the fauna of South Africa
b. illustrate a possible source of food for large carnivores
c. contrast with the habits of the antelope
d. suggest the size of antelope herds

4. The word 'carnage' in line "As this able naturalist remarked to me, the carnage each day in Southern Africa must indeed he terrific!" refers to the

a. number of animals killed by hunters
b. number of prey animals killed by predators
c. number of people killed by lions
d. damage caused by large animals

5. To account for the 'surprising' number of animals in a 'country producing so little food', Darwin, the author of *The Voyage of the Beagle* suggests all of the following as partial explanations except

a. food which is a concentrated source of nutrients
b. large area for animals to forage in
c. mainly carnivorous animals
d. food requirements have been overestimated

6. Darwin, the author of *The Voyage of the Beagle*, quotes Burchell's observations about South America in order to

a. counter a popular misconception
b. describe a region of great splendor
c. prove a hypothesis
d. illustrate a well-known phenomenon

7. Darwin, the author of *The Voyage of the Beagle*, apparently regards Dr. Smith as

a. reliable and imaginative
b. intrepid and competent
c. foolhardy and tiresome
d. incontrovertible and peerless

Appendix E. The Original Baumeister, Twenge, and Nuss (2002) Primes.

Future Alone Condition: You're the type you will end up alone later in life. You may have friends and relationships now, but by your mid-20s most of these will have drifted away. You may even marry or have several marriages, but these are likely to be short-lived or not continue into your 30s. Relationships don't last, and when you're past the age when people are constantly forming new relationships, the odds are you'll end up being alone more and more.

Future Belonging Condition: You're the type who has rewarding relationships throughout life. You're likely to have a long and stable marriage and friendships that will last into your later years. The odds are you'll always have friends and people who care about you.

Future Misfortune Condition: You're likely to be accident prone later in life. You might break an arm or leg a few times, or maybe be injured in a car accidents. Even if you haven't been accident-prone before, these things will show up later in life, and the odds are you will have a lot of accidents.

Appendix F. Comparisons of participants who believed the primes.

Comparison of non-lonely and lonely young adults who believed the loneliness prime.

	Non-lonely		Lonely	
	M	*SD*	*M*	*SD*
Age	18.97_a	.80	19.52_b	1.06
Gender (0 = Female)	.38	.49	.58	.50
Education	1.21	.41	1.23	.50
Trails A	24.91	7.30	25.48	8.41
Stroop X	84.21	10.85	85.55	8.41
Reading Span	3.37	.86	3.27	.85
Vocabulary	29.21	3.52	30.10	4.09

Note. Table entries without subscripts do not differ at $p < 0.05$; entries with subscripts differ at $p < 0.05$.

Comparison of non-lonely and lonely older adults who believed the loneliness prime.

	Non-lonely		Lonely	
	M	*SD*	*M*	*SD*
Age	70.90	6.54	73.24_b	7.63
Gender (0 = Female)	$.13_a$	.34	$.35_b$	.48
Education	3.63	1.06	3.27	1.17
Trails A	35.05_a	12.20	41.11_b	14.91
Stroop X	71.43_a	10.78	66.54_b	13.14
Reading Span	2.75	.77	2.80	.85
Vocabulary	35.75	2.18	35.54	3.18

Note. Table entries without subscripts do not differ at $p < 0.05$; entries with subscripts differ at $p < 0.05$.

Comparison of young adults who believe by prime condition.

	Alone		Belong		Misfortune		None	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	18.86	.38	18.94	.56	19.10	1.29	19.52	1.06
Gender	$.86_{a}$	.38	$.18_{b}$	.39	$.40_{a,b}$	.52	$.58_{a}$	.50
Education	1.00	.00	1.35	.49	1.10	.32	1.23	.50
Trails A	27.43	10.91	23.41	5.03	25.70	7.85	25.48	8.41
Stroop X	85.57	14.11	82.24	9.63	86.60	10.92	85.55	8.41
Reading Span	3.07	.53	3.41	.87	3.50	1.03	3.27	.85
Vocabulary	29.71	3.30	28.82	3.61	29.50	3.81	30.10	4.09

Note. Table entries without subscripts do not differ at $p < 0.05$; table entries with different subscripts differ at $p < 0.05$.

Comparison of older adults who believe by prime condition.

	Alone		Belong		Misfortune		None	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	70.89	7.93	70.00	5.41	72.55	7.50	73.24	7.63
Gender	.00	.00	.15	.37	.18	.41	.35	.48
Education	3.11	1.17	3.90	.91	3.55	1.13	3.27	1.17
Trails A	36.00	11.10	32.50	12.15	38.91	13.09	41.11	14.91
Stroop X	71.89	6.59	72.25	10.55	69.55	14.18	66.54	13.14
Reading Span	3.06	.68	2.73	.80	2.55	.76	2.80	.85
Vocabulary	35.00	2.24	36.25	2.05	35.45	2.34	35.54	3.18

Note. Table entries without subscripts do not differ at $p < 0.05$; table entries with different subscripts differ at $p < 0.05$.