Original Article

Women Want the Heavens, Men Want the Earth

Gender Differences in Support for Life Extension Technologies

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Abstract

Efforts are being made in the field of medicine to promote the possibility of indefinite life extension (ILE). Past research on attitudes towards ILE technologies showed that women and more religious individuals usually have more negative attitudes towards ILE. The purpose of this research was to investigate whether gender differences in attitude towards indefinite life extension technologies can be partially explained by religiosity, afterlife beliefs and general attitudes towards science. In four Studies (N = 5,000), undergraduate participants completed self-report questionnaires measuring their support for life extension as well as religiosity, afterlife beliefs, and attitude towards science (in Study 3). In all studies men supported ILE more than

women, whereas women reported greater belief in an afterlife. The relationship between gender and attitude towards ILE and was only partially mediated by religiosity (Studies 2-4) and by attitudes towards science (Study 3).

Keywords: life extension; gender differences; religion; attitudes towards science.

Women want the heavens, men want the earth: Gender differences in support for life extension technologies

Would you like to live forever? Scholars around the world have suggested that technological improvement in the fields of cellular biology and cybernetics may open the possibility for Indefinite Life Extension (ILE; e.g., De Grey & Rae, 2007). If this came true, ILE technologies could eventually promote human health in various ways, such as curing cancer cells or repairing the degenerative effects of aging on other bodily organs. Nevertheless, while ILE may sound like a highly desirable goal for some, others may find this idea much less appealing. For example, previous studies show that people who are low in religious beliefs are more likely to support the development of ILE than those who do have a strong religious belief (e.g., Ballinger, Tisdale, Sellen, & Martin, 2017; Lifshin, Greenberg, Soenke, Darrell, & Pyszczynski, 2017; Partridge, Underwood, Lucke, Bartlett, & Hall, 2009). Research also indicates that men have more positive attitudes towards ILE than women (e.g., Arber, Vandravalab, Dalya, & Hampson, 2008; Dragojlovic, 2013; Partridge, Lucke, Bartlett, & Hall, 2011). Interestingly, there is also evidence that there are gender differences in religious beliefs, as women tend to be more religious and believe in the afterlife more than men (e.g., De Vaus & McAllister, 1987; Ferraro & Albrecht-Jensen, 1991; Francis, 1997). In addition, some evidence suggests that women have less positive attitudes towards science than men do (e.g., Osborne, Simon, & Collins, 2003; Weinburgh, 1995). Could gender differences in religiosity and attitudes towards science explain why women support ILE less than men? Our goal was to examine gender differences in attitudes towards ILE, and how they may relate to peoples religious beliefs, as well as attitudes towards science. By better understanding gender differences in attitude towards ILE, we may learn more

about why people may or may not support its research and development, and perhaps even anticipate reactions to its implementation, in the event that ILE begins to become a reality.

Humans have a long history of seeking immortality. The oldest piece of known written literature, *The Epic of Gilgamesh*, dating back to around 5000 years ago, follows a hero on his quest to avoid death and obtain immortality. Psychological theory and research has demonstrated that human awareness of mortality leads to powerful motivation to keep thoughts of death out of awareness, by adhering to cultural worldviews, which offer them ways to immortalize themselves (e.g., Becker, 1973; Lifton, 1979; Greenberg, Pyszczynski, & Solomon, 1986; Jung, 1936; Solomon, Greenberg, & Pyszczynski, 2015). For example, research conducted to test ideas derived from terror management theory (for a review see Greenberg, Vail, & Pyszczynski, 2014; Solomon et al., 2015) has demonstrated that when people think about death they are more likely to defend their cultural worldviews and seek ways to feel immortal (e.g., Greenberg et al., 1990; Greenberg, Kosloff, Solomon, Cohen, & Landau, 2010); that bolstering of immortalizing worldviews reduces the cognitive accessibility of death related thoughts (e.g., Dechesne et al., 2003), and that threatening the validity of cultural worldviews enhances death thought accessibility (Schimel, Hayes, Williams, & Jahrig, 2007).

The human drive for immortality has taken a variety of forms through the ages, with religious belief in an immortal soul being perhaps the most direct and prominent one. In 2012, the Pew Research Center reported that 84% of the world's population had a religious affiliation (Pew Research Center, 2012) with more than 77% of surveyed individuals adhering to a religion that explicitly promises an afterlife (i.e., Christianity, Islam, Hinduism, Buddhism). Since religious afterlife beliefs deal directly with the problem of death, by convincing people that it is

not the end of existence, they are particularly useful for terror management (e.g., Du & Chi, 2016; Soenke, Greenberg, & Landau, 2013).

However, humans also have a rich history of attempts to extend life directly (e.g., Gruman, 1966). Although, as far as we know, no such effort has ever been able to extend life indefinitely, scientific advances in modern times may offer a new route to immortality — indefinite life through bio-medical technologies. For example, stem cell researchers have developed ways to prolong the life of cells (e.g., Bodnar et al., 1998), or even repair damage in bone marrow or the gut, and in special cases stem cells can repair complex organs such as the heart (Lovell-Badge, 2001; National Institute of Health, n.d.). Even prosthetic limbs have made substantial advances in the last decade. Researchers are finding ways to add pressure sensors to limbs and connect sensors to nerves so that amputees can feel objects in ways never thought possible until recently (e.g., Fischmann, 2014).

While ILE technologies may be especially beneficial and may ultimately help cure diseases and postpone aging (e.g., De Grey & Rae, 2007), reactions to indefinite life extension (ILE) efforts are mixed. While some scholars question the ultimate feasibility of ILE (e.g., Estep et al., 2006) others argue that even if ILE were attainable it would disrupt social order, undermine government programs, and lead to lives of unending boredom and spiritual angst (e.g., Fukuyama, 2002; Kass, 2001). On the other hand, some scholars argue that the process is inevitable and society should prepare itself (e.g., Banks & Fossel, 1997; De Grey & Rae, 2007).

Beyond philosophical, economic, ethical, and legal concerns regarding ILE, there may be an even more basic difference in support for ILE endeavors. In particular, there may be basic differences between those who hold religious and afterlife beliefs and those who do not. For example, previous studies conducted within the framework of terror management theory showed

that after thinking about death, people who are less religious are more likely to support the development of ILE than those who are more religious and that this effect is mediated by the reduction of afterlife beliefs that thoughts of ILE produce (Lifshin et al., 2017). If one believes one‘s spirit is not going to continue to exist in a literal way after death, one is more likely to support efforts to make ILE possible.

Another variable that was previously found to relate to attitudes towards ILE is gender. Several studies have found that women may indeed be less accepting of life extension technologies than men. Arber et al. (2008) found that older women were about twice as likely to oppose using medical technologies to extend life at its final stages. In this interview based study, men reported being more concerned with extending their life at all cost, while women were more concerned with how this may affect others. Partridge et al. (2011) replicated the gender difference in attitudes towards ILE in a younger and more aged-diverse sample and found that men were also more likely to want to actually use life extension technologies than women. Similar findings were observed among subsequent studies from other counties (e.g., Dragojlovic, 2013). Relatedly, studies have also found that women were overall less supportive of the use of invasive medical assistive technologies (i.e., a medical stent) that may help prolong life (e.g., Alagöz, Ziefle, Wilkowska, & Valdez, 2011; Ziefle & Schaar, 2011). Thus it seems that there is a consistent effect for gender on attitudes towards ILE technology. However, these gender differences in preferences for ILE technologies are still not well understood.

One possibility is that these effects are in fact related, and gender differences in religiosity may explain the gender differences in attitude towards ILE. It has been well documented that women are generally more religious than men (e.g., Francis, 1997). Women attend church more: for example, in Australia (De Vaus & McAllister, 1987), Canada (Gee,

1991), England (British Council of Churches, 1986; Davies, Watkins & Winter, 1991), and the U.S. (Ploch & Hastings, 1994; Winseman & Min, 2002). Women are more likely to believe in God: for example in the U.K. (Francis & Kay, 1995) and in the U.S. (e.g., Thompson, 1991; Newport, 2012); and are more likely to believe in an afterlife: for example in the U.K. (Greeley, 1992) and in the U.S. (Ferraro & Albrecht-Jensen, 1991). Researches have offered several different explanations for these gender differences, such differences in socialization and gender roles (e.g., De Vaus & McAllister, 1987; Levitt, 1995), or personality variables such as tendency towards risk taking and psychoticism (e.g., Miller & Hoffmann, 1995; Penny, Francis, & Robbins, 2015; for a review of theories about gender differences in religiosity see e.g., Francis, 1997). The present studies were not, however, designed to test among these explanations. Rather our focus was on the potential implications of this gender difference for how women and men may feel about ILE. The female preference for religiosity and belief in the afterlife suggests that they may have less desire for indefinite life extension. After all, if one believes death is not the end, forestalling it should be less important.

Another possibility is that gender differences in attitudes towards ILE are related to gender differences in attitudes towards science. Previous research has shown that women generally have more negative attitudes towards science than men (e.g., Jones, Howe, & Rua, 2000; Osborne et al., 2003; Weinburgh, 1995). These may stem from a gender difference in attitudes towards STEM (science, technology, engineering and mathematics) fields in general (e.g., Whitley, 1997), that relates to socio-cultural sex roles (e.g., Diekman, Brown, Johnston, & Clark, 2010; Eagly & Wood, 1999; Linn, & Hyde, 1989) and to gender-science related stereotypes that help perpetuate this difference (e.g., Nosek et al., 2009; Spencer, Steele, & Quinn, 1999; Stout, Dasgupta, Hunsinger, & McManus, 2011). Regardless of the reason,

women's more negative attitudes towards science relatively to men may perhaps explain their more negative attitudes towards ILE technologies.

The purpose of the present set of studies was therefore to explore gender differences in attitude towards ILE and consider religiosity and attitude towards science as potential mediators of these differences. Our general hypothesis was that gender differences in ILE would be at least partially explained by gender differences in religiosity, afterlife beliefs, and attitudes towards science. We assessed the possibilities that 1) women would report being more religious, believing more in the afterlife and having more negative attitudes towards science then men; 2) religiosity and afterlife beliefs would be negatively correlated with support for ILE and attitude towards science would be positively related to support for ILE; 3) women would support ILE less than men; and 4) controlling for gender differences in religiosity, afterlife belief or attitudes towards science would attenuate the association between gender and support for ILE.

Study 1

Method

***Participants*.** The data were collected in introductory psychology classes at the University of Arizona as a part of large survey of undergraduates' attitudes, interests, and personality traits. Thus, our modal participant's level of education was high school completed, and currently college freshmen. The participants completed the questionnaires voluntarily during their class. After excluding the results of participants that who had missing data (n = 14) on the variables of interest, the results from 1020 participants were analyzed. [1] Of these, 671 were women (65.8%) and 349 were men. The mean age of the participants was 19.03 (SD = 2.30). The participants' religious affiliation was as follows: 635 participants (62.1% of the sample) were Christian, 74 reported being atheist (7.3%), 142 indicated agnostic (13.9%), 61 were Jewish

(6%), 15 were Buddhist (1.5%), 12 were Hindu (1.2%), 11 were Muslim (1.1%), 13 were Mormon (1.3%), 50 indicated other (5%), and 7 did not report religious affiliation (0.7%).

Procedure and materials. After filling out demographic information such as gender and age, participants were first asked about their level of religiosity ("How important are your religious beliefs to you?"; *1 = Not at all important, 9 = Extremely important*), and then about their belief in an afterlife ("Do you think that you will live once again after you die [e.g., in a heaven or through reincarnation]?"; *1 = Certainly not, 9 = Certainly yes*). After that, participants' attitude towards ILE was assessed using a single item ("To what extent do you support scientific efforts to slow the aging process and consequently increase the human lifespan greatly?"; *1 = Not at all support, 9 = Completely support*). Finally the participants filled out the religious orientation scale (Allport & Ross, 1967), which measures intrinsic and extrinsic religiosity. [2]

Results and Discussion

Preliminary Pearson correlations revealed that the participants' gender (men = 1, women = 0) was correlated with support for ILE (r = .19, p < .001), religiosity (r = -.14, p < .001), and afterlife belief (r = -.13, p < .001), although less so with intrinsic or extrinsic religiosity (r = -.07, p = .023, and, r = .03, p = .347, respectively). Interestingly however, support for ILE was not correlated with importance of religiosity (r = -.05, p = .084), afterlife belief (r = -.02, p = .546), intrinsic religiosity, (r = -.02, p = .631). Afterlife belief, importance of religiosity, and intrinsic religiosity were all correlated with each other (rs > .47, ps < .001). There was also a weak correlation of ILE and extrinsic religiosity (r = .09, p = .004). The means and standard deviations of these measures are reported in Table 1.

To further explore these gender differences we conducted a MANOVA test for differences in support for ILE, religiosity and afterlife beliefs between men and women. The

difference was statistically significant at the multivariate level, $F(1, 1016) = 20.34$, $p < .001$, *Hotelling's Trace* = .06. The univariate analyses showed that, as expected, women reported more afterlife belief than men ($M = 6.45$, $SE = .10$, 95% CI [6.26, 6.65] vs. $M = 5.75$, $SE = .14$, 95% CI [5.49, 6.02]), $F(1, 1018) = 17.10$, $p < .001$, $\eta p^2 = .02$, and more religiosity than men ($M = 5.51$, $SE = .10$, 95% CI [5.33, 5.70] vs. $M = 4.78$, $SE = .13$, 95% CI [4.52, 5.04]), $F(1, 1018) = 19.85$, $p < .001$, $\eta p^2 = .02$. However, men reported more support for ILE compared to women ($M = 6.32$, $SE = .11$, 95% CI [6.10, 6.54] vs. $M = 5.48$, $SE = .08$, 95% CI [5.32, 5.64]), $F(1, 1018) = 36.56$, $p < .001$, $\eta p^2 = .04$. The means and 95% confidence intervals of all the measures for men and women are summarized in Table 2).

After finding that men support ILE more than women, and that women believe in the afterlife more than men, we wanted to test whether men support ILE more than they believe in the afterlife, and if women believe in the afterlife more than they support ILE, using a 2 (men = 1, women = 0) × 2 (support for ILE vs. belief in the afterlife), mixed within-between subject ANOVA. This analysis yielded a significant interaction between gender and the type of immortality strategy, $F(1, 1018) = 49.69$, $p < .001$, $\eta p^2 = .05$. Follow up analyses using paired *t* tests separately for men and women showed that while women reported more afterlife belief than support for ILE ($M = 6.45$, $SE = 1.00$ vs. $M = 5.48$, $SE = .08$, respectively), $t(670) = 8.00$, $p < .001$, *Cohen's d* = .31, men supported ILE more than they believed in the afterlife ($M = 6.32$, $SE = 1.12$ vs. $M = 5.75$, $SE = .15$, respectively), $t(348) = 2.94$, $p = .004$, *Cohen's d* = .16. [3]

Lastly, we tested whether religiosity and afterlife belief mediated the gender difference in support for ILE. The 95% confidence intervals obtained for the indirect effects were estimated by bootstrapping with 10,000 resamples using the SPSS software macro *PROCESS* (Hayes, 2012). The indirect effect of gender on support for ILE through religiosity or afterlife was not

different from zero, 95% CI [-.18, .06], and [-.44, .35], respectively. Thus religiosity and afterlife belief did not mediate the difference between men and women in support for ILE.

These results indicate that there are clear gender differences in level of support for ILE, religiosity and afterlife beliefs. While women reported being more religious and believing in the afterlife more than men, men reported supporting ILE more than women. There was also a within-subject effect, in which women reported more belief in the afterlife than support for ILE and men preferred ILE more than reported afterlife belief.

Despite this, counter to our hypothesis neither religiosity nor afterlife belief accounted for the gender difference in attitude towards ILE. We suspect that this may be due to the fact that our ILE item did not indicate that the life extension would indeed be *indefinite*, which would make it more threatening to afterlife beliefs. Thus, it may be that extending life greatly does not conflict with religiosity as it would if life extension was indefinite.

Study 2

Study 2 was conducted as a replication of Study 1 using a slightly different measure of support for ILE, one that indicated clearly that life extension would be *indefinite*. We hypothesized that as in Study 1, women would report more afterlife belief and religiosity than men and support afterlife beliefs more than they support ILE. At the same time, we expected men would show the opposite pattern: more support for ILE than women and more support for it than their belief in the afterlife. We also hypothesized that since we had framed life extension as indefinite, religiosity and afterlife belief would mediate the gender differences in support for it.

Method

***Participants*.** Data were collected in the same manner as Study 1. After excluding the results of participants with missing data (n = 129), the results of 1366 participants were analyzed.

Of these 936 were women and 430 were men. The mean age of the participants was 18.58 (*SD* = 1.61). The participants' religious affiliation was as follows: 811 participants (59.4% of the sample) were Christian, 121 were atheist (8.9%), 216 were agnostic (15.8%), 78 were Jewish (5.7%), 29 were Buddhist (2.1%), 10 were Hindu (0.7%), 12 were Muslim (0.9 %), 15 were Mormon (1.1%), and 74 indicated other (5.4%).

***Procedure and materials*.** The procedures and materials in the study were identical to the ones' used in Study 1, except that we changed the last word of the ILE item from "greatly" to "indefinitely" (i.e., "To what extent do you support scientific efforts to slow the aging process and consequently increase the human lifespan indefinitely"). Finally the participants filled out the religious orientation scale (Allport & Ross, 1967), which measures intrinsic and extrinsic religiosity.

Results and Discussion

Preliminary Pearson correlations revealed that support for ILE was negatively related to religiosity, $r = -.11$, $p < .001$, intrinsic religiosity, $r = -.12$, $p < .001$, and afterlife belief, $r = -.09$, $p < .001$ (afterlife belief and religiosity were correlated, $r = .44$, $p < .001$). This may be due to the fact that ILE was framed as "indefinitely" as opposed to "greatly" (in study 1). Importantly, the participants' gender (men = 1, women = 0) was correlated with support for ILE, $r = .21$, $p < .001$, religiosity, $r = -.11$, $p < .001$, intrinsic religiosity, $r = -.09$, $p < .001$, and afterlife belief, $r = -.14$, $p < .001$.

To test our hypotheses we first conducted a MANOVA test for differences in support for ILE, religiosity and afterlife beliefs between men and women. The test was statistically significant at the multivariate level, $F(1, 1362) = 27.94$, $p < .001$, *Hotelling's Trace* = .06. The univariate analyses showed that, as expected, women reported more afterlife beliefs than men (*M*

= 6.29, *SE* = .09, 95% CI [6.13, 6.46] vs. *M* = 5.52, *SD* = 2.72, 95% CI [5.27, 5.77]), *F*(1, 1364) = 25.82, $p < .001$, $\eta p^2 = .02$, and more religiosity than men (*M* = 5.56, *SE*= .09, 95% CI [5.39, 5.72] vs. *M* = 4.96, *SE* = .13, 95% CI [4.71, 5.20]), *F*(1, 1364) = 15.89, $p < .001$, $\eta p^2 = .01$. [4] However, men reported more support for ILE compared to women (*M* = 6.40, *SE* = .10, 95% CI [6.12, 6.60] vs. *M* = 5.44, *SE* = .07, 95% CI [5.30, 5.58]), *F*(1, 1364) = 60.56, $p < .001$, $\eta p^2 = .04$.

Next we ran the 2 (men = 1, Women = 0) × 2 (Support for ILE vs. Belief in the afterlife), mixed within-between subject ANOVA. This analysis yielded the expected gender by type of immortality strategy interaction, *F*(1, 1364) = 73.63, $p < .001$, $\eta p^2 = .05$. Follow up comparisons using paired-t tests indicated that while women reported more afterlife belief than support for ILE (*M* = 6.29, *SE* = .08 vs. *M* = 5.44, *SE* = .07, respectively), *t*(935) = 7.87, $p < .001$, *Cohen's d* = .26, men supported ILE more than they believed in the afterlife (*M* = 6.40, *SE* = .10 vs. *M* = 5.52, *SE* = .13, respectively), *t*(429) = 4.85, $p < .001$, *Cohen's d* = .23.

Finally, we ran mediational analyses with religiosity and afterlife belief. A preliminary test indicated that when both religiosity and afterlife mediators were entered in the model afterlife became a non-significant mediator. Thus, religiosity better explained gender differences in support for ILE than afterlife. Consequently, we entered religiosity as the final mediator in the model (also considering that the mediators were related, *r* = .44, $p < .001$). Bootstrapping with 10,000 resamples yielded a statistically significant indirect effect of gender on support for ILE via religiosity, M_{effect} = .04, 95% CI [.02, .09]. Looking at the specific paths in regression analyses (See Figure 1 for a graphical depiction of the model), men reported less religiosity than women (A path), *t*(1364) = 3.99, $p < .001$, $\beta = -.11$; religiosity was negatively correlated with support for ILE (B path), *t*(1363) = 3.28, $p = .001$, $\beta = -.09$; men supported ILE more than women (C path), *t*(1364) = 7.78, $p < .001$, $\beta = .21$; and controlling for religiosity slightly

attenuated the effect of gender on ILE, (C' path), $t(1363) = 7.41$, $p < .001$, $\beta = .20$. Repeating this analysis with intrinsic religiosity yielded a similar indirect effect, $M_{effect} = .04$, 95% CI [.02, .08].

These results replicated the findings from Study 1, in which women showed generally more preference for religious paths to immortality than men, and compared to the degree to which they supported ILE. In contrast, men seem to favor ILE over religious paths to immortality, and more so than women did.

We did find some evidence for a mediational effect for religiosity, as men were less religious than women, and religiosity was negatively correlated with support for ILE, leading to a positive indirect effect. However, the indirect effect as well as the mediational attenuation of the direct effect were small and are not likely to explain much of the gender differences in ILE. Therefore, to test for alternative mediators for this effect we conducted Study 3.

Study 3

Study 3 was conducted to replicate the effects of Studies 1 and 2 while exploring an additional mediator: attitude towards science. Considering that many studies report gender differences in attitude towards science (e.g., Osborne et al., 2003; Weinburgh, 1995), and that ILE technologies are scientifically based (and consequently attitudes toward science is related to attitude toward ILE; e.g., Dragojlovic, 2013), we hypothesized that it may also account for the gender difference in support for ILE. Thus in addition to our hypothesis regarding gender differences in attitude towards ILE and the mediating role of religiosity, we also hypothesized that 1) men would support ILE more than women; 2) men would report more support for science than women; 3) more support for science would be positively correlated with support for ILE; 3); 4) statistically controlling for attitude towards science would attenuate the relationship between gender and ILE and there would be an indirect effect of gender on ILE via attitude towards

science. Thus, we expected that the gender difference in attitude towards ILE would be partially mediated by both the participants' level of religiosity and their attitude towards science.

Method

Participants. After excluding participants with missing data (n = 9), results of 1021 participants were analyzed. Of these 627 were women and 394 were men with a mean age of 19.21, (SD = 2.68). The sample included 615 Christians (60.1%), 81 atheists (7.9%), 149 agonists (14.6%), 69 Jews (6.8%), 16 Buddhists (1.6%), 9 Hindus (0.9%), 5 Muslims (0.5 %), 10 Mormons (1%), 55 participants with other religious affiliations (5.4%), and 12 participants did not report religious affiliation (1.2%). In this Study, we also measured the participants' ethnic background. Four hundred and thirty two students reported being European-American (43.8%), 226 were Hispanic-American (22.1%), 42 were African-American (4.1%), 85 were Jewish-American (8.6%), 67 were Asian-American (6.6%), 17 were Native-American (1.7%), 9 were Pacific-Islander-American (0.9%), 9 were Arab-American (0.9%), 100 reported "other" (8.8%), and 34 participants did not report their ethnicity (3.3%).

Procedure and materials. The procedures and materials in the study were the same as in Studies 1 and 2 (ILE was measured as it was in Study 2), with the addition of two questions regarding attitude towards science (Francis & Greer, 1999). Specifically, participants rated the degree to which they agreed with two statements reflecting positive attitude towards science (i.e., "I'd like to understand more about scientific explanation for things"; "Science is very important to the future of mankind"; *1 = strongly disagree, 7 = strongly agree*). We did not include the measures of extrinsic and extrinsic religiosity considering that in Studies 1 and 2 our 1-tem of religiosity was also highly correlated with intrinsic religiosity (r = .75, and r = .76, ps < .001),

and that the relationship between religiosity and ILE was roughly the same using either measure of religiosity, we decided to keep the more parsimonious measure for studies 3 and 4.

Results and Discussion

Initial analyses replicated the results from Studies 1 and 2. As in the previous studies, a MANOVA analysis, $F(3, 1017) = 18.51$, $p < .001$, $\eta p^2 = .05$, indicated that women reported more afterlife beliefs than men ($M = 6.08$, $SE = .10$, 95% CI [5.88, 6.27] vs. $M = 5.46$, $SE = .13$, 95% CI [5.22, 5.71]), $F(1, 1019) = 14.67$, $p < .001$, $\eta p^2 = .01$, and more religiosity than men ($M = 5.52$, $SE = .10$, 95% CI [5.32, 5.72] vs. $M = 4.60$, $SE = .13$, 95% CI [4.36, 4.85]), $F(1, 1019) = 32.55$, $p < .001$, $\eta p^2 = .03$. In contrast, men reported more support for ILE than women ($M = 6.36$, $SE = .10$, 95% CI [6.17, 6.56] vs. $M = 5.71$, $SE = .08$, 95% CI [5.55, 5.87]), $F(1, 1019) = 26.25$, $p < .001$, $\eta p^2 = .03$.

Similarly, as in the previous Studies, a 2 (men = 1, women = 0) × 2 (Support for ILE vs. Belief in the afterlife), mixed subject ANOVA yielded a significant gender by type of immortality strategy interaction, $F(1, 1019) = 37.27$, $p < .001$, $\eta p^2 = .04$. Women reported more afterlife belief than support for ILE ($M = 6.09$, $SE = .10$ vs. $M = 5.71$, $SE = .08$), $t(626) = 2.87$, $p < .005$, *Cohen's d* = .11. Finally, men supported ILE more than they reported believing in the afterlife ($M = 6.36$, $SE = .11$ vs. $M = 5.46$, $SE = .13$), $t(393) = 5.48$, $p < .001$, *Cohen's d* = .23.

We also found that in line with previous research, men had a more positive attitude towards science than women ($M = 5.81$, $SE = .06$, 95% CI [5.70, 5.91] vs. $M = 5.55$, $SE = .04$, 95% CI [5.47, 5.64]), $t(1019) = 3.60$, $p < .001$, *Cohens' d* = .23. In accordance with our expectations, attitude towards science was positively related to support for ILE, $r = .28$, $p < .001$.

Finally, to test our mediational hypothesis, we ran a mediation analysis to estimate the indirect effects of gender on ILE via religiosity and attitude towards science. The indirect effects

were significant for both religiosity, M_{effect} = .05, 95% CI [.01, .10], and attitude towards science M_{effect} = .12, 95% CI [.06, .19]. Looking at the specific paths in regression analyses (See figure 1), men reported less religiosity (A1 path), $t(1019) = 5.71$, $p < .001$, $\beta = -.18$, and a more positive attitude towards science (A2 path), $t(1019) = 3.60$, $p < .001$, $\beta = .11$. Religiosity was negatively correlated with support for ILE (B1 path), $t(1017) = 2.02$, $p = .044$, $\beta = -.06$, and attitude towards science was positively correlated with support for ILE (B2 path), $t(1017) = 8.44$ $p < .001$, $\beta = .25$. Gender was positively correlated with support for ILE (C path), $t(1019) = 5.12$, $p < .001$, $\beta = .16$, and controlling for religiosity and attitude towards science attenuated the effect of gender on ILE, (C' path), $t(1017) = 3.92$, $p < .001$, $\beta = .12$.

These results replicated the findings from Study 1 and 2, in which women reported supporting ILE less than men, while having stronger belief in the afterlife than men. More importantly however, we found that the gender differences in attitude towards ILE was partially mediated by attitude towards science and religious beliefs. Men's more positive attitude towards science seemed to have had a relatively large impact on their positive support for ILE technologies.

Study 4

The purpose of Study 4 was to replicate the gender differences in ILE again using a different, multi-item scale for attitude towards ILE. Because the prior three studies all relied on the same single item measure of this attitude, if this study shows the same relationships, it would show that the findings are not limited to the one measure. We included a reverse scored item in a scale to help ensure the measure is not being affected by a positive response bias. And, of course, the multi-item measure allows us to assess internal consistency of the instrument.

***Participants*.** As in Studies 1-3 the sample included introductory students from the University of Arizona. After excluding participants with missing data (n = 33), results of 1593 participants were analyzed. Of these 1021 were women and 572 were men, with a mean age of 18.58 (SD = 1.64). The sample included 919 Christians (57.9%), 159 atheists (10%), 252 agonists (15.8%), 62 Jews (3.9%), 30 Buddhists (1.9%), 18 Hindus (1.1%), 45 Muslims (2.8 %), 25 Mormons (1.6%), 77 participants with other religious affiliations (4.8%), and 6 participants did not report religious affiliation (0.4%). In this study, using slightly different labels than Study 3, the ethnic distribution was fairly similar: 1113 students reported "white" (43.8%), 115 reported "black or African American" (7.2%), 179 were Asian (4.1%), 49 American Indian/ native Alaskan (3.1%), 21 Native Hawaiian or Pacific Islander (1.3%), 260 reported "other" (16.3%), and 34 participants did not report their ethnicity (3.3%). 480 participants considered themselves as Hispanic (30.1%), 1095 considered themselves not Hispanic (68.7%), and 18 participants did not respond to this question (1.1%).

***Procedure and materials*.** The procedure was the same as in Studies 1-3, aside from the fact that students completed it on laptops while in class, instead of in a paper-pencil format (data was collected on Qualtircs.com).

The materials were also roughly similar to Studies 1-3, aside from the fact that ILE was measured using five items: 1) "To what extent do you support scientific efforts to slow the aging process?"; 2)"To what extent do you support scientific efforts to increase the human lifespan indefinitely?"; 3) If technology existed to extend the human lifespan indefinitely, I would want to use it"; 4) "I believe that scientists should not pursue efforts to extend the human life indefinitely."(reversed coded); 5) To what extent would you like the opportunity to use technologies to extend your own life indefinitely?". Responses were made on the same 1-9 scale

as in previous studies (items 3 and for had *1= completely disagree; 9 = completely agree*). A mean score of these items were computed so that higher scores reflect more support for ILE (α = .89), The other difference is that in this study we didn't measure afterlife beliefs or belief in science as mediators. [5]

Results and Discussion

Initial analyses replicated the results from Studies 1-3, as men reported more support for ILE than women (M = 5.58, SE = .08, 95% CI [5.41, 5.74] vs. M = 4.85, SE = .06, 95% CI [4.73, 4.96]), $F(1, 1591) = 57.65$, $p < .001$, $\eta p^2 = .035$. And again women reported more religiosity than men (M = 5.49, SE = .09, 95% CI [5.32, 5.65] vs. M = 4.78, SE = .11, 95% CI [4.56, 5.01]), $F(1, 1591) = 25.30$, $p < .001$, $\eta p^2 = .016$.

We then again test our mediational hypothesis, by estimating the indirect effect of gender on ILE via religiosity. The analysis showed that the indirect effects were significant, $M_{effect} = .04$, 95% CI [.02, .08]. Looking at the specific paths in regression analyses (See figure 1), men reported less religiosity (A path), $t(1591) = 5.03$, $p < .001$, $\beta = -.13$, and religiosity was negatively correlated with support for ILE (B path), $t(1590) = 3.68$, $p < .001$, $\beta = -.09$. Gender was positively correlated with support for ILE (C path), $t(1591) = 7.59$, $p < .001$, $\beta = .19$, and controlling for religiosity and attitude towards science slightly attenuated the effect of gender on ILE, (C' path), $t(1590) = 7.10$, $p < .001$, $\beta = .18$.

These results replicated the findings from Studies 1-3 in which women reported supporting ILE less than men while having stronger belief in the afterlife than men, this time with a 5-item measure of support for ILE. We also replicated the small mediational role that religiosity had in the effect. Overall the results of this study further establish the robustness of these effects.

General discussion

The goal of the current research was to further investigate gender differences in support for ILE, religiosity, afterlife beliefs, and attitudes towards science. In Study 1, we found that men supported the development of life extension technologies more than women and that their level of support was comparably higher than their level of reported afterlife beliefs. In contrast, women showed the opposite pattern: they were more religious and reported more belief in an afterlife than men, and they reported higher levels of afterlife belief than support for life extension technology. In Study 2, we edited the measure of support for life extension so that it would explicitly include the word "indefinite", and replicated the findings from Study 1, and also found a statistically significant small mediational pattern in which religiosity explained a portion of the gender difference in support for ILE. In Study 3, we examined whether an alternative mediator – attitude towards science – could also help explain this gender difference. Indeed, we found that attitude towards science was associated with higher support for ILE, and that gender differences in attitude towards science (women reported more negative attitudes towards science than men), partially mediated the gender differences in ILE. This effect was independent of and somewhat larger than the mediational effect of religiosity. In Study 4, we replicated the gender difference in attitude towards ILE using a different measuring scale, and also replicated the small mediational effect of religiosity. Taken together, these results indicate that women support ILE less than men and that this effect is partially explained by women's less positive attitude towards science, as well as by stronger levels of religiosity (although to a lesser degree).

These findings are largely congruent with past research showing differences between women and men in attitudes towards medical life extension technology (e.g., Arber et al. 2008; Partridge et al., 2011) as well as attitudes towards invasive medical assistive technologies (e.g.,

Alagöz et al., 2011; Ziefle & Schaar, 2011). Surprisingly, men and women also differed in their attitudes towards anti-aging technologies in items that did not mention the words indefinite life extension, despite the fact that women are more regular consumer's anti-aging products.

These results are also congruent with some prior findings regarding the negative association between religiosity and attitudes towards ILE (Ballinger et al., 2017; Partridge et al., 2009). However, our mediational studies indicate that only a small portion of the gender difference in attitudes towards ILE is explained by religiosity. Thus, further research should investigate other mechanisms that may explain the gender difference in preference for ILE. Similarly, although there were consistent differences between women and men in the degree to which they believe in the afterlife (in studies 1-3), and there was a consistent opposite deference in the mean of support for ILE over mean of belief in the afterlife among men and women, belief in the afterlife in itself was not a significant mediator of the gender difference in ILE. These findings might be conceived as somewhat inconsistent with previous research by Lifshin (et al., 2017) that indicated that belief in the afterlife can sometimes mediate differences in attitudes towards ILE. However, the study by Lifshin et al did show that afterlife beliefs were related to ILE (and significant mediators) only under experimental conditions in which mortality was made salient, or if ILE was presented as plausible in the lifetime of the participants (or when both things occurred together), but not when mortality was not primed and ILE was not explicitly presented as plausible. Thus, considering that we did not have such conditions in our study, the current results are not inconsistent with the prior findings.

Our findings from Study 3 suggest that differences between men and women in attitudes towards science may play a somewhat larger role in the effects than differences in religiosity (or afterlife beliefs). This result lines up with previous research indicating that attitudes towards

science have a substantial impact on attitudes towards radical life extension technologies (e.g., Dragojlovic, 2013). Nevertheless, a large portion of the difference between women and men in attitudes towards ILE remains unexplained by these mediators, and therefore further research should investigate how other potential mediators, such as attitudes towards death (e.g., Wong, Reker, & Gesser, 1994), attitudes towards the body, or risk aversion may also relate to the effect.

This study has several limitations. First, our samples consisted of mostly young college students with a mean of about 19 years of age and therefore might not generalize to the entire population. It is possible that older adults would be more supportive of ILE technologies, as they start dealing with the consequences of aging. In contrast, older populations might like ILE less because ILE is something that may be available only in the remote and unknown future (if at all); thus, they might not be as likely to be able to benefit from it. Nevertheless, considering that prior studies have not found a significant difference in attitudes towards ILE as a function of age (e.g., Partridge et al., 2009), this limitation may not be a consequential one. Another limitation is that our sample consisted mostly of American participants who live in a relatively technology friendly cultural-environment. It is possible that cultural and social differences in attitude towards technology would also be related to attitude towards ILE. Although previous research has found converging findings from the UK and Australia (e.g., Arber et al., 2008; Partridge et al., 2009, 2011), further research may investigate this possibility in non-Western cultures. Lastly, the fact that this study is correlational limits our ability to make causal inferences from the results. Although clearly attitude towards ILE cannot affect people's gender and is unlikely to cause differences in attitude towards science or religiosity in men and women, it may still be the case that some other third variable is causing this effect. Thus, future research could replicate and extend these findings in an experimental setting. For example, it may be useful to carefully

explore the emotions and thoughts that arise in the minds of men and women when they learn about ILE technology. Additionally, it may be useful to explore whether gender differences in obtaining STEM (science, technology, engineering and mathematics) related jobs or expectations regarding such opportunities might account for differences in attitudes towards science.

Despite these limitations, this study has several important implications. First, this study provides a strong replication of previous studies (e.g., Arber et al., 2008; Dragojlovic, 2013; Partridge et al., 2011) that found gender differences in attitude towards ILE. Recognizing that these differences are robust may be important for understanding psychological and social issues related to the emergence of ILE technologies. Second, the research shows that both attitude towards science and religiosity partially mediate this effect. Understanding what drives gender differences in attitude toward ILE may eventually help researchers understand what might impact or alter attitudes toward it.

A substantial amount of time and effort is being put into various medical lines of research and technologies in an effort to slow or even reverse the aging process, and in other ways forestall death and extend life far beyond its current temporal limits. Thus, in the foreseeable future, modern societies will have many political, ethical, social and pragmatic issues to address as this work continues to advance. Understanding how gender, religiosity, and attitudes toward science affect the way people think and feel about such advances could play an important role in the processes by which societies make their decisions regarding resources directed toward extending life and regulations regarding the use of such emerging medical technologies.

In addition to promoting our understanding of attitudes towards ILE, understanding gender differences in support for ILE may ultimately help understand gender differences in other domains that relate to health or science, and even gender differences in religiosity and afterlife

beliefs. Finally, we did consistently find a difference in support for ILE over afterlife among men and support for afterlife over ILE in women. Thus, it seems likely that the gender differences in ILE are related to gender differences in preference for ways to address concerns about mortality.

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Footnotes

[1] We did not consider students under the age of 18 as participants in accordance with the university policy to not use their data. We also did not consider foreign students (n = 112) as participants since a large majority of them did not speak English well enough to properly complete the materials (including them did not change any of the results; in Study 4 we did not have this measure so several foreign students were included in the sample).

[2] As evidence for the validity of our 1-item measure of religiosity we also conducted several analyses showing its convergent validity with different measures of religiosity. First, the 1-item measure was strongly correlated with intrinsic religiosity (Allport & Ross, 1967), in Study 1, r = .75, p < .001, and in Study 2, r = .76 p < .001. Second, an ANOVA comparing atheists, agnostics and people with religious affiliations (all grouped together) on our 1-item religiosity measure yielded a highly statistically significant effect in all four studies, all Fs > 240.74, ps < .001, all ηp^2 > .330. Atheists (M_{study1} = 2.18, M_{study2} = 2.45, M_{study3} = 2.18, M_{study4} = 2.34) and agnostics (M_{study1} = 2.89, M_{study2} = 3.02, M_{study3} = 2.99, M_{study4} = 2.79) differed from people with religious affiliations (M_{study1} = 6.09, M_{study2} = 6.35, M_{study3} = 6.08, M_{study4} = 6.29), all ps < .001 (differences were also significant between atheists and agnostics, ps < .040). Thus, we are confident that this measure accurately captured the participants' level of religiosity.

[3] The results of these within subject comparisons in each study were the same when we used Z scores instead of raw values (all paired ts > 3.90, ps < .001). We eventually kept the raw values since they are more informative.

[4] These results were roughly the same if we used the measure of intrinsic religiosity, and thus to reduce multicollinearity in the MANOVA, we focused on the 1-item of religiosity. We do

not report the results of all these differences here in order to save space, and to maintain consistency across studies (Studies 3 and 4 did not include this measure).

[5] This change was done because this data were collected as a part of a different project about ILE and morality, and they were used to supplement the current findings with a multi-item measure of ILE.

Table 1

Means and standard deviations of the main research measures: support for indefinite life extension (ILE) technologies, religiosity and belief in the afterlife between women and men across the 4 different Studies (N = 5,000).

Measure	*Study 1*	*Study 2*	*Study 3*	*Study 4*
Support for ILE	5.76 (2.13)	5.74 (2.16)	5.96 (2.01)	5.11 (1.89)
Rel.	5.26 (2.51)	5.37 (2.61)	5.17 (2.54)	5.23 (2.70)
Belief in the afterlife	6.21 (2.58)	6.05 (2.64)	5.84 (2.52)	--

Note. ILE = Indefinite life extension; Rel. = Religiosity. All measures were measured using a 1-9 scale, with higher numbers meaning more support for ILE/ importance of religiosity/ belief in the afterlife. Note that in Study 1, the measure of ILE did not include the words "indefinitely" and in Study 4 support for ILE was measured using a different scale.

Table 2

Means and 95% confidence intervals (CI) of the research dependent variables: support for indefinite life extension (ILE) technologies, religiosity and belief in the afterlife between women and men across the 4 different Studies (N = 5,000).

Measure		*Study 1*	*Study 2*	*Study 3*	*Study 4*
Support for ILE	Women	5.48 [5.32, 5.64]	5.44 [5.30, 5.58]	5.71 [5.55, 5.87]	4.85 [4.73, 4.96]
	Men	6.32 [6.10, 6.54]	6.40 [6.12, 6.60]	6.36 [6.17, 6.56]	5.58 [5.41, 5.74]
Rel.	Women	5.51 [5.33, 5.70]	5.56 [5.39, 5.72]	5.52 [5.32, 5.72]	5.49 [5.32, 5.65]
	Men	4.78 [4.52, 5.04]	4.96 [4.71, 5.20]	4.60 [4.36, 4.85]	4.78 [4.56, 5.01]
Belief in the afterlife	Women	6.45 [6.26, 6.65]	6.29 [6.13, 6.46]	6.08 [5.88, 6.27]	--
	Men	5.75 [5.49, 6.02]	5.52 [5.27, 5.77]	5.46 [5.22, 5.71]	--

Note. ILE = Indefinite life extension; Rel. = Religiosity. 95% CI's displayed in prentices [low limit, high limit]. In each study, all differences between women and men were statistically significant at $p < .001$. Note that in Study 1, the measure of ILE did not include the words "indefinitely" and in Study 4 support for ILE was measured using a different scale.

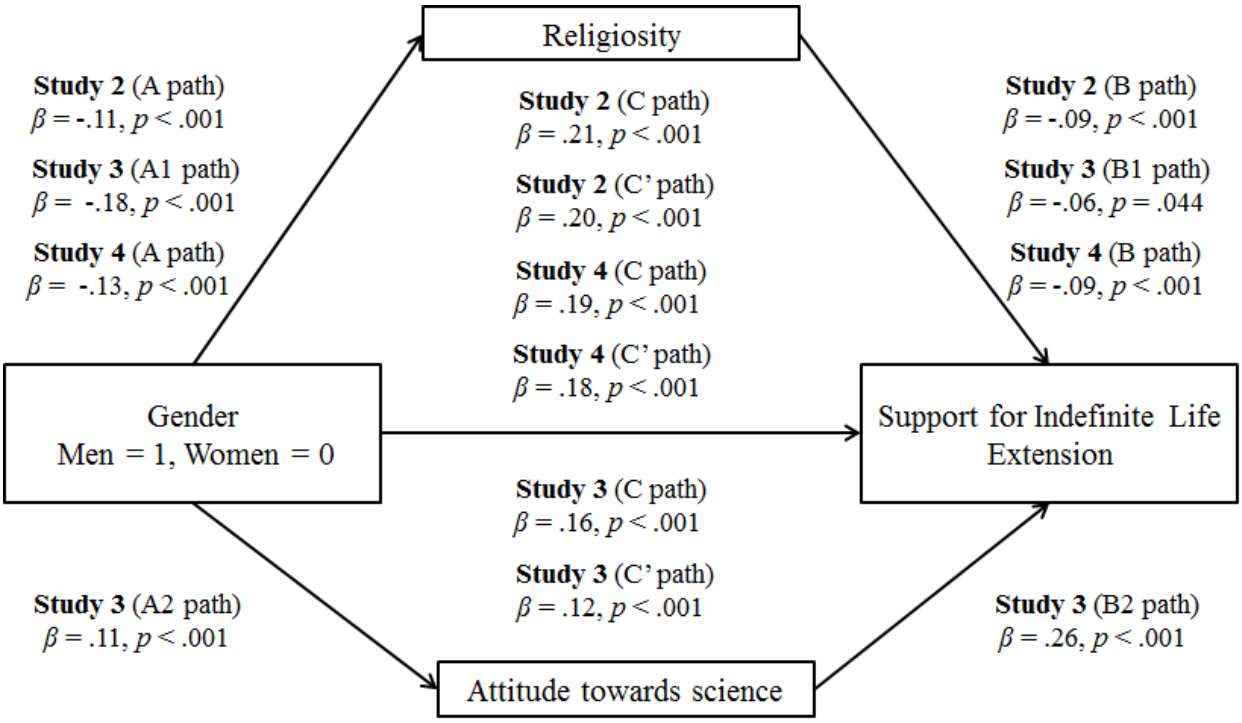

Figure 1. A depiction of the indirect effects from Studies 2 (N = 1020), 2 (N = 1366), and 4 (N = 1593). On the top are the path coefficients of the indirect effects of gender on support for ILE via religiosity, which were significant in Study 2: *Mean effect* = .04, 95% CI [.02, .09], in Study 3: *Mean effect* = .05, 95% CI [.01, .10], and in Study 4, *Mean effect* = 04, 95% CI [.02, .08]. On the bottom are the path coefficients of the indirect effects of gender on support for ILE via attitude towards science, *Mean effect* = .12, 95% CI [.06, .19].