Attitudes Toward Germline Engineering

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Abstract

Attitudes toward human germline engineering were assessed across three studies. In Pilot Study One, we evaluated participant familiarity ratings for a preliminary item pool consisting of potential targets of germline modification in order to screen out unfamiliar targets. The results were used to screen out 54 of 170 items. In Pilot Study Two, we used participant representativeness ratings to validate categorizations for the remaining items by removing items that were indifferently representative of specific goals (therapeutic or enhancing) and types (physical, cognitive, or personality) of germline modifications. The results also indicated that for many items, the distinction between cognitive and personality characteristics broke down, leading us to collapse these categories into a new type category based on general psychological traits. In Study One, we compared mean approval ratings for potential targets of germline engineering sorted according to the goal of modification (therapeutic or enhancing) and the type of characteristic being targeted (physical or psychological). The results indicated that approval was higher for therapeutic modifications than for enhancing modifications, and higher for modifications targeting physical traits than for those targeting psychological traits. A regression analysis showed that approval correlated positively with knowledge, Big Five Agreeableness, and negatively with perceived risk and female gender. Contrary to expectations, approval did not correlate with psychological essentialism or Big Five Openness. Implications and limitations are discussed.

Contributions

I conducted the background research and reviewed the relevant literature. Dr. Fekken and I formulated the research questions and hypotheses, as well as the methodology and overall organization of the study. My colleagues in the Personality Assessment Lab helped to brainstorm items for our preliminary item pool and my thesis committee made the recommendation of including a pilot study to screen out unfamiliar items.

I was responsible for creating or adapting all measures except the personality inventory. I recruited and ran all participants. Dr. Fekken supervised all phases of this study and provided key guidance during the data cleanup and subsequent analyses. She also edited all drafts of this thesis. No research assistants were employed to help conduct this study.

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Chapter 1 – Introduction

Recent scientific developments in the area of human genetic engineering will have significant social and personal consequences (Fukuyama, 2002; McKibben, 2004; Rifkin, 1998) and therefore represent an important new domain of attitude research that is currently understudied in the psychological literature. One such new area of development, germline engineering, will allow parents to permanently modify the genotype of their children in order to screen out genetic disadvantages and even add or modify more desirable characteristics. This new technology raises questions similar to hot topic issues such as eugenics, designer babies, and cloning, and therefore represents an important new area of research. Evaluating attitudes toward germline engineering would provide a framework through which we may better understand general attitudes toward this new form of biotechnology as well as related individual differences.

DNA, Genetic Engineering, and Biotechnology

The completion of the human genome project in 2003, just 50 years after Watson and Crick discovered the sequence of DNA, has been deemed a landmark event in the history of science (White House Press Release, 2000 June 5). The culmination of a lengthy international research effort, the complete sequence of the human genome was hailed as a means of understanding our fundamental physical and functional composition in a first step toward identifying and preventing genetic diseases (Venter et al., 2001). The genome sequence is the cornerstone of genomics, the study of an organism's entire set of genetic information, and its completion opens the door to new possibilities in human genetic engineering. There are two methods available to those who seek to modify human genotypes in order to change our traits: somatic engineering and germline

engineering. Somatic genetic engineering techniques add genes to non-germinal cells in order to treat disorders. Since these changes are made to cells other than the egg or sperm cells, they affect only the targeted individual and are not passed on to the next generation. Germline genetic engineering techniques modify the cells of sperm, ova, and very early embryos in order to treat diseases or modify and enhance desirable characteristics. Another important distinction between somatic and germline modifications is that because germline modifications target germinal cells, they are therefore heritable and would be carried forward to all future generations. When these techniques are used specifically to treat diseases they may also be respectively referred to as somatic gene therapy and germline gene therapy.

An understanding of attitudes toward germline engineering is important because making permanent genetic modifications will have great social and personal consequences. The larger field of biotechnology is expected to become the biggest and most influential global industry (Fukuyama, 2002) and our age has been nicknamed "the biotech century" (Rifkin, 1998). Experts in the field have watched earlier predictions about in vitro fertilization, embryo screening, and gene therapy come true, and have projected a steady progression in the availability and acceptance of genetic modifications. As the field progresses, somatic and germline engineering techniques will be used to screen out genetic diseases, alter physical traits, improve cognitive faculties, and even modify personality traits (McKibben, 2004; Silver, 1997; Wilson & Haslam, 2009). Concurrent with the steady growth in media coverage of genomics, there has been a rapid increase in recent research on attitudes and perceptions of this important new field (Pin & Gutteling, 2008). However, little attention has been granted to the study of attitudes

toward germline engineering. Because of its potential to make permanent genetic changes to important physical and psychological traits, germline engineering stands out as especially important and understudied.

Related Research: Attitudes Toward Genetic Engineering

Although there is a dearth of psychological research on attitudes toward germline engineering, there is a literature on attitudes toward various applications of general genetic engineering. The literature itself does not flow from any particular theoretical perspective, but might be conceptualized as evidence of a hierarchy of values. Research has demonstrated that support for genetic engineering declines as the target of modification moves from micro-organisms, to plants, to animals, and finally to humans (Chen & Raffan, 1999; Dawson & Schibeci, 2003; Lock & Miles, 1993; Surmeli & Sahin, 2010). Chen and Raffan's (1999) survey of UK and Taiwanese secondary school students found that 83% of Taiwanese students and 80% of UK students approved of genetic modifications to plants, whereas only 66% of Taiwanese and 58% of UK students approved of modifications aimed at animals. Among Australian high school students, Dawson and Schibeci (2003) found that over 90% of students approved of the use of microorganisms in biotechnology and between 71% and 82% approved of applications involving plants. Approval for different human applications ranged between 42% and 45%, and approval for animal applications was lowest of all, ranging between 34% and 40%. While this study shows some minor variance in terms of the order of approval ratings for different applications of genetic engineering, it should be noted that two of the survey items used in calculating approval ratings for animal applications involved inserting genes from either plants or humans into animals or animals' eggs; the very low

approval ratings for these items could be caused by the combination of target organisms in a given item. Lock and Miles (1993) found that, among British secondary school students, approval for genetic engineering was highly dependent on context, with high average approval for applications involving microbes and plants, moderate approval for farm animals, and lowest approval for procedures involving both human and animal cells. Using a questionnaire adopted from Dawson and Schibeci (2003), Surmeli and Sahin (2010) found that Turkish university students approved of modifications to microorganisms more than modifications to either plants or animals. Ultimately, what emerges from the literature is a pattern of declining approval as the target of genetic modification moves from microorganisms to plants, then to animals, and then to humans.

Attitudes May Vary as a Function of the Type of Trait Targeted

So far we know that overall approval for modifications to humans is low, but there could be considerable attitudinal differences across distinct types of human applications. Specifically, approval ratings for using germline engineering to modify different types of human traits (e.g. physical traits, cognitive traits, and personality) may differ substantially. While I know of no current research on germline engineering that explores this possibility, there are some relevant findings on the willingness of young, healthy individuals to take drugs usually reserved for clinical populations. This trend, referred to as enhancement pharmaceuticals or pharmacological enhancement, revolves around the desire of healthy individuals to use drugs designed to improve cognitive abilities or emotional traits. Some examples of drugs being used in this way include selective serotonin reuptake inhibitors (Kramer, 1993), beta-blockers (Jefferson, 1996), stimulants such as Ritalin, Dexedrine, and Adderall (McCabe, Knight, Teter, &

Wechsler, 2005), and donepezil (Yesavage et al., 2002), a drug designed to treat memory loss in patients with Alzheimer's disease. Of particular relevance is a drug study (Riis, Simmons, & Goodwin, 2008) that used a series of questionnaire studies to look at attitudes toward the use of pharmaceuticals to enhance cognitive abilities and personality traits. This study showed that we are more reluctant to target traits we see as more fundamental to self-identity, and that social and emotional traits are seen as more fundamental than cognitive abilities.

The literature on attitudes toward genetic engineering therefore shows that approval is context-dependent. We become increasingly wary as the target of the procedure moves up the chain of life from microbes to humans. The pharmacological enhancement literature suggests that there is a strong interest in using drugs to enhance healthy psychological functioning, and the study by Riis et al. (2008) shows that there is usually a specific pattern in the type of traits we are interested in altering, with greater interest in enhancing cognitive traits than in enhancements to social and emotional traits. If there is a distinct pattern in the type of trait that we are willing to alter by using drugs, then we have reason to believe that a similar pattern would emerge in our preferences toward possible trait modifications using germline engineering.

Attitudes May Vary as a Function of the Goal of the Procedure

Attitudes toward human germline engineering may also vary as a direct function of the goal of the genetic modification. Most authors assign the goal of modification to one of two distinct categories: therapeutic modifications and enhancement modifications (Walters & Palmer, 1997; Wilson & Haslam, 2009). Therapeutic modifications aim to eliminate genetic disadvantages by screening out diseases and genetic predispositions to

unwanted medical conditions. Enhancement modifications aim to improve physical and mental characteristics beyond "normal" levels. Although there is a lack of attitudinal research focusing specifically on germline modifications, research on basic genetic engineering has shown that people generally favour therapeutic modifications more than enhancement modifications (Chen & Raffan, 1999; Hampel, Pfenning, & Peters, 2000; Meisenberg, 2009; Meister, Finck, Stobel-Richter, Schmutzer, & Brahler, 2005). In a survey of high school students in the UK and Taiwan, Chen and Raffan (1999) found significantly stronger support for genetic modifications aimed at disease resistance than for modifications aimed at enhanced growth in food crops. Hampel et al. (2000) found strong support in Germany for medical applications of genetic engineering such as disease treatment, cancer therapy, and prenatal diagnostics, but strong aversion to applications designed to enhance agricultural crops. Meisenberg (2009) investigated attitudes toward pre-implantation genetic screening in a mixed sample of American and international medical students. His respondents rated genetic interventions to prevent diseases such as cystic fibrosis, diabetes, asthma, and Alzheimer's as more acceptable than non-medical interventions that allowed parents to control for normal variation of either physical or psychological traits. Meister et al. (2005) looked at attitudes toward pre-implantation genetic diagnosis in Germany and found high acceptance for medical risks and life-threatening illnesses but low acceptance for non-medical cases such as for selection of sex or intelligence. The common theme that emerges is one of greater approval for therapeutic applications that seek to correct for genetic disadvantages and lower approval for enhancement applications to otherwise healthy individuals.

Attitudes May Vary as a Function of Individual Differences

The field of human genetic engineering has quickly become a topic of passionate debate and a lightning rod for controversy because of the personal and social consequences involved with genetic modifications (Fukuyama, 2002; McKibben, 2004; Wilson & Haslam, 2009). Beyond understanding the main dimensions along which attitudes may vary, there are several specific demographic and psychological variables that relate to approval for genetic engineering. There is no particular framework that has been related to this field, but there is proof that well-established demographic variables and personality structures are worthy of investigation.

Individual Differences: Gender

A key demographic finding is that women often express lower approval than men for various applications of genetic engineering (Chen & Raffan, 1999; Hampel, Pfenning, & Peters, 2000; Lock & Miles, 1993; Prokop, Leskova, Kubiatko, & Diran, 2007). Of the potential demographic variables, gender may be especially relevant in terms of its relationship to approval for germline engineering because, in comparison to men, women have always been more connected to their offspring. Any change to the child would have profound and direct implications for its mother. Chen and Raffan (1999) found gender differences in approval among UK secondary students but not among Taiwanese secondary students, with women reporting significantly less support than men for different applications of biotechnology. Hampel et al. (2000) found that more women than men assessed genetic engineering negatively or ambivalently, and more men assessed it positively. Lock and Miles (1993) found that among British secondary school students, women were less supportive of genetic engineering of farm animals. Prokop et

al. (2007) looked at a sample of teacher's college students in Slovakia and found that females presented significantly more negative concerns about biotechnology than did males. These studies suggest that women will show lower average levels of approval for germline engineering compared to males.

Individual Differences: Related Knowledge

The relationship between scientific knowledge and approval of genetic engineering and biotechnology is not simple. Several studies have found a relationship between general knowledge of science or biology and approval for applications of biotechnology (Chen & Raffan, 1999; Sturgis, Cooper, & Fife-Schaw, 2005; Surmeli & Sahin, 2010). In a British Social Attitudes Survey of 3,426 adults, Sturgis et al. (2005) found that the relationship between general knowledge and specific forms of approval varies, but general knowledge did in fact predict more favourable opinions toward genetic science and its applications. At a more specific level of knowledge, Chen and Raffan (1999) found that among UK secondary school students, those studying biology were more optimistic about both biotechnology and genetic engineering compared to students not studying biology. It should be noted that these authors measured only general knowledge of biology, not knowledge of genetics or biotechnology, and they did not find the same results in Taiwanese students, who showed similarly high levels of approval regardless of their education. Surmeli and Sahin (2010) used a questionnaire to assess variations in attitudes toward biotechnology by university major and found significantly stronger support among biology students compared to medical students and other science students. It is difficult to draw a simple conclusion from these studies, as Sturgis et al. (2005) indicate that general scientific knowledge may predict positive

attitudes toward genetic engineering but both Chen and Raffan (1999) and Surmeli and Sahin (2010) found that knowledge of biology was a stronger predictor of attitudes than general scientific knowledge.

Other studies have demonstrated a relationship between approval for applications of genetic engineering and more specific forms of related knowledge (Allum, Sturgis, Brunton-Smith, & Tabourazi, 2008; Bal, Samanci, & Bozkurt, 2007; Hampel, Pfenning, & Peters, 2000; Klop & Severiens, 2007). In a sample of Turkish university students, Bal, Samanci, and Bozkurt (2007) found that increases in the number of biology and genetics courses taken correlated with higher approval of genetic engineering. Klop and Severiens (2007) report similar findings in a Dutch sample, where greater understanding of biotechnology and genetic engineering correlated with greater acceptance and approval of these fields and their applications. Even more telling is a meta-analysis of 193 surveys of the public understanding of science (Allum et al., 2008) that found a positive correlation between knowledge of genetics and attitudes toward genetically modified food, but no correlation between general knowledge of science and attitudes toward genetically modified food. Given that a typical student is unlikely to study genetics and biotechnology without some training in basic biology, these studies suggest that knowledge of these specific areas should be considered in addition to general knowledge of science and knowledge of biology in looking at attitudes toward germline engineering.

Individual Differences: Psychological Essentialism

Another individual difference variable that may account for differences in approval of germline engineering is psychological essentialism. This construct refers to the idea that categories have underlying essences (Medin & Ortony, 1989) that are

natural, universal, discretely bounded, and stable over time (Haslam, Rothschild, & Ernst, 2000). In a review article looking at essentialism and social motivation, stereotyping and intergroup bias, Prentice and Miller (2007) conclude that essentialist thinking reduces one's motivation to change essentialized groups or their members, including one's self. This suggests that a person who believes in the essentialism of the human species itself will be less willing to change themselves or members of their group, and therefore less likely to approve of doing so by using genetic engineering.

Although psychological essentialism has not been directly studied as a predictor of attitudes toward genetic engineering, the underlying concepts appear repeatedly in the literature. In an examination of arguments used by the most prominent advocates and opponents of biotechnology, Wilson and Haslam (2009) showed that differences in non-scientific definitions of human nature typically hinged on assumptions of essentialism, "the idea that species are natural kinds, with essential, universal traits" (p. 248). Advocates of genetic engineering believe that there is no fixed human essence and that our species is malleable and dynamic. They repudiate the "natural" as an ethical norm, they emphasize human qualities that place us "beyond nature" such as our rationality, and they view our characteristics as modular and separate. Opponents of genetic engineering believe to varying degrees in a fixed human essence and protection of the "natural" as a guide to what is good and right. They emphasize qualities that place humans "in nature" such as emotion, and they focus on the indivisible wholeness of human nature. If expert scientists and bioethicists are sharply divided in terms of their belief in the essentialism of the human species itself then it is reasonable to believe that a measure of psychological essentialism will also differentiate laypeople's attitudes toward genetic engineering.

Individual Differences: Perceived Risk

Another variable that is expected to account for attitudinal differences is individual differences in perceived risks associated with germline engineering. Many authors report informally that their participants are aware of some risks inherent with various applications of genetic engineering (Chen & Raffan, 1999; Bal, Samanci, & Bozkurt, 2007). In an examination of the relationship between attitudes toward genetic engineering and factors such as individual differences in risk perception, religion, moral orientation, views on technology, and political orientation, Urban and Pfenning (2000) determined that risk perception is the most important determinant of attitudes toward genetic engineering. Although we cannot say if individual differences in risk perception are also the most important determinant of attitudes toward germline engineering, a recent examination of attitudes toward four applications of genetic engineering (Crne-Hladnik, Peklaj, Košmelj, Hladnik, & Javornik, 2009) revealed that perceived risks were greater for germline therapy for hemophilia than for somatic therapy for hemophilia. This was the only study on record which compared risk perception for the same application of somatic and germline therapy, and if considered with Urban and Pfenning's (2000) findings, suggests that individual differences in risk perception may be an especially important factor in attitudes toward germline engineering.

It is also worth considering that germline engineering may pose risks to the targeted child and their descendants, as well as to society in general. Risk to one's child and grandchildren would certainly be a prominent consideration for anyone who might use technology to change their child's genome, but this technology may also pose a risk to all future generations by threatening social justice and creating new forms of

inequalities. Indeed, many opponents of genetic engineering (Fukuyama, 2002; McKibben, 2004; Sandel, 2007) bring up social and political concerns based on a compromised natural order. These findings suggest that any valid measure of perceived risk associated with germline engineering should therefore be comprised of risks to one's own children and grandchildren, as well as risks to future generations of people in general.

Individual Differences: Personality

In addition to these variables, it is interesting to consider the role that personality may play in shaping attitudes toward germline engineering. A conventional view of personality would say that a stable combination of characteristic traits influences a person's emotion, behaviour, and thinking, and that these individual differences correspond to differences in specific attitudes. Therefore it is surprising that not a single study reviewed here attempted to relate attitudes toward genetic engineering to personality. It could very well be the case that there is no specific pattern between personality and attitudes toward biotechnology, genetic engineering, pre-implantation genetic diagnosis, human cloning, and related topics. But without any point of reference in the related literature it is impossible to say if this is the case, or if such a relationship actually exists and has simply remained unexplored. For these reasons I believe it is prescient to include a standard measure of personality in our survey of attitudes toward germline engineering.

I expect a relationship to emerge between the Big Five factor of Openness to experience and attitudes toward germline engineering because Openness involves a preference for novelty, intellectual curiosity, and preference for nontraditional values

(Ashton, Lee, Vernon, & Jang, 2000) as well as independence and nonconformity (De Raad, Hendriks, & Hofstee, 1992). Many advocates of genetic engineering emphasize human rationality, intelligence, and technology as the basis of our human nature and they frequently focus on genetic modifications to improve intellectual capacities like memory, concentration, and control over emotions (Bostrom, 2005; Brooks, 2002, Savulescu, 2003.) Although Big Five Openness also measures unrelated aspects such as aesthetic sensitivity and attention to feelings, to a large degree it is based on a willingness to try new activities, an intellectual curiousity, and an inclination to reexamine traditional values. These aspects of Openness capture the attitude of prominent advocates of genetic engineering and they may therefore underlie a relationship between Openness and attitudes toward germline engineering in laypeople.

Research Outline

Although psychological research has begun to paint a picture of our attitudes toward genetic engineering, attitudes toward the newer subfield of germline engineering remain poorly understood. A better understanding of these attitudes is important because of the wide range of characteristics that may be modified, as well as the fact that modifications made using this technology are genetically heritable. This study will attempt to address the paucity of research on attitudes toward germline engineering by exploring how attitudes vary according to the type and goal of modification, as well as by examining the relationship between overall approval and specific individual differences. Research will be conducted in three phases. In Pilot Study One, we will evaluate participant familiarity ratings for a preliminary item pool consisting of potential targets of germline modification in order to screen out unfamiliar targets. In Pilot Study Two, we

will use participant representativeness ratings to validate goal and type categorizations for our items. In Study One, we will compare approval ratings for potential targets of germline engineering according to the goal of modification and the type of characteristic being targeted. We will also investigate the role of gender, perceived risk, related knowledge, psychological essentialism, and Big Five personality traits as predictors of attitudes toward germline engineering.

Chapter 2 – Pilot Study One

Participants

Thirty-three participants were recruited from the participant pool for Introductory Psychology at Queen's University. In this group there were 6 males and 27 females. Average age was 18.18 years with a standard deviation of 1.18 years (N=33).

Materials

Familiarity Questionnaire. This questionnaire consisted of 170 items asking participants to rate how familiar they were with a given potential target of germline engineering using a 7-point Likert-type scale. This initial pool of potential targets of germline engineering was generated based on traits, diseases, abilities and characteristics that are known or strongly believed to have a genetic basis. Including the author, a total of eight people generated potential items for this item pool after having been thoroughly briefed on the aim and design of the study.

Procedure

Familiarity ratings were collected online using SurveyMonkey, a website that allows users to conduct online surveys. Participants read a letter of information, provided consent and basic demographic information, then completed a familiarity rating for each

item. Participants were provided with a brief outline of germline engineering and the nature of their task:

> The completion of the human genome project has opened the door to two new forms of human genetic engineering: somatic engineering and germline engineering. Somatic engineering techniques modify cells and tissues of living persons in order to treat diseases. Germline engineering techniques modify the cells of sperm, ova, and very early embryos to allow parents to modify the genotype of their children. Modifications from somatic engineering are not genetically heritable and would therefore affect only the targeted individual. Because germline engineering techniques target germinal cells, any modifications made in this manner are genetically heritable and would be carried forward to all future generations.
>
> There are many possible applications of germline engineering, including screening out diseases, modifying the body, and even modifying psychological characteristics. Some potential targets of modification are well known while others are not very well known. The goal of this study is to assess how well known are some potential targets of germline engineering. What follows is a list of potential targets of germline engineering. Please use the scale provided to indicate how familiar you are with each target of germline engineering.

For each potential target of germline engineering that followed, participants were asked "how familiar are you with the given disease, trait, ability or characteristic?" A 7-point Likert-type scale was used to collect familiarity ratings, with a score of one designated as "completely unfamiliar," a score of four as "somewhat familiar" and a score of seven as "completely familiar." In the analysis that followed, all items were classified into one of six categories according to their purported goal and the type of trait being targeted. Goals were classified as either therapeutic or enhancement, and type of trait being targeted was classified as either physical, cognitive, or personality. Mean familiarity ratings and standard deviations were calculated for each of these six categories. See Appendix A for familiarity ratings.

Chapter 3 – Pilot Study One Results

Familiarity Ratings

Data analysis was conducted in order to refine the item pool. We began by deleting items that were one or more standard deviations lower than the average familiarity rating according to category assignment. This led to the deletion of 27 items from a pool of 170. Given that our aim was to significantly reduce our initial item pool, and considering that this procedure led to the deletion of as few as three items in three of six categories, we continued to refine the item pool by deleting the next three to five items with the lowest mean familiarity score in each category. An additional three to five items per category were deleted based on this procedure. This led to the deletion of an additional 27 items, bringing the total number of deleted items to 54, about one third of the initial item pool. These deleted items included potential targets of germline engineering such as Tay-Sachs disease, Huntington's chorea, psychopathy, Asperger's syndrome, panic disorders, fertility, spatial reasoning, perfect pitch, and extreme shyness. See Table 1 for mean familiarity scores and standard deviations for the 116 items retained for use in Pilot Study Two, sorted according to goal and type of trait targeted. Mean familiarity ratings and standard deviations were relatively similar across the six categories, and a similar proportion of items was deleted from each category. This left us with a list of 116 potential targets of germline engineering. See Appendix B for a finalized list of the 116 items to be used in Pilot Study Two.

Table 1

Mean Familiarity Scores and Standard Deviations for Items Retained from Pilot Study One

Type-Goal Subcategory	Mean	Standard Deviation
Physical Therapies	4.47	.53
Cognitive Therapies	4.39	.49
Personality Therapies	4.69	.37
Physical Enhancements	5.48	.41
Cognitive Enhancements	5.12	.29
Personality Enhancements	5.42	.25

Conclusions

The results of our first Pilot Study indicated that participants were unfamiliar with approximately one third of the items in our preliminary item pool of potential targets of germline engineering. Of 170 potential items, 54 were deleted and 116 were retained for use in the second Pilot Study in order to gauge how participants categorized these procedures. We thus met our goal of refining the initial item pool. The purpose of Pilot Study Two is to confirm that these items are correctly grouped into goal (therapeutic or enhancement) and trait type (physical, cognitive, and personality) categories.

Chapter 4 – Pilot Study Two

Participants

Forty participants were recruited from the participant pool for Introductory Psychology at Queen's University. This group was comprised of 5 males and 35 females. Average age was 18.21 with a standard deviation of 0.92 years (N=39).

Materials

Representativeness Ratings. Participants were asked to provide ratings of perceived degree of fit, or representativeness, for 116 potential applications of germline engineering. Each item was listed as a potential target of germline engineering for which participants used a 7-point Likert-type scale to rate the degree to which they thought the item was representative of therapeutic and enhancement goals, and of physical, cognitive, or personality-based trait types. There were thus five representativeness ratings collected for each item, which ensured that participants were not led to associate a given target with any particular type or goal of intervention.

Procedure

Pilot Study Two was conducted online using the website SurveyMonkey. All participants saw a letter of information and then gave consent, along with basic demographic information, before providing ratings of perceived fit. The letter of information explained the basics of germline engineering and presented the idea that targets of germline engineering may be classified according to type and goal; no indication of our research hypothesis was given. All participants were instructed as follows:

> There are many possible applications of germline engineering, including screening out diseases, modifying the body, and even modifying psychological characteristics. Genetic modifications made using germline engineering can be grouped according to the type of trait being modified

> and the goal of modification. There are three broad categories of trait types: physical traits, cognitive traits, and personality traits. There are two goals of modification: therapy and enhancement. Therapeutic goals aim to eliminate genetic disadvantages by screening out genes associated with diseases as well as predispositions to diseases and certain medical conditions. Enhancement modifications aim to improve physical and mental characteristics beyond "normal" levels.
>
> Our goal in this study is to measure general consensus as to how each application of germline engineering should be categorized. On the following pages you will see a list of potential targets of modification. Using the scales provided, please indicate the degree to which you think the use of germline engineering to screen out, modify, or control the genes associated with the given target is representative of the various types and goals of germline engineering.

Items were presented in a random order consistent across participants in order to ensure that the items did not appear to be grouped together according to type or goal of intervention. Participants read a list of 116 potential targets of germline engineering and indicated the degree to which they thought each target was representative of different goals (therapeutic and enhancement) and types (physical, cognitive, or personality) of germline engineering. Participants used a 7-point Likert-type scale to indicate whether they agreed or disagreed that the goal was therapeutic or enhancing, and that it represented a physical, cognitive, or personality type modification. The scale labels used were "strongly disagree" for a value of one, "neither agree nor disagree" for a value of four, and "strongly agree" for a value of seven.

Chapter 5 – Pilot Study Two Results

Representativeness Ratings

Means and standard deviations were calculated for each item's five representativeness ratings. The goal of data analysis was to keep only the 15 items with the highest perceived degree of fit in each goal and type category, leaving 90 items spread across 6 categories to be used in Study One. As a starting point, we required that each item have a higher mean score for the modification type and goal for which it was

written than for the irrelevant types and goal. For example, applications for which the goal was intended to be either therapeutic or enhancing had to also be perceived that way by our participants. From here, we screened out targets that were not distinctly representative of any type or goal by removing the items with the smallest difference between type scores or goal scores.

Data analysis for 27 physical therapy items led to the elimination of 12 items which were rated as equally or indifferently representative of therapeutic and enhancement goals and of physical, cognitive, or personality traits. This left 15 remaining items that were seen as distinctly representative of therapeutic goals and of physical types of traits. Based on the same procedure, 5 of 20 physical enhancement items were eliminated, leaving 15 items that were seen as distinctly therapeutic and physical. Applying our elimination rule thus led to the retention of a sufficient number of items for both physical therapy and physical enhancement categories.

Data analysis for items hypothesized to be representative of cognitive therapies and enhancements proved to be more complicated. Applying our elimination rule led to the deletion of five items that participants rated as indifferently representative of therapy and enhancing goals. This left only 11 cognitive therapy items remaining. With items conceived of as cognitive enhancements, our elimination rule caused us to delete two items that were seen as equally representative of different types of traits, leaving 15 of 17 items remaining.

Analysis of representativeness ratings for items hypothesized to be representative of personality therapies and enhancements led to similarly unexpected results. Ratings for 15 personality therapy items indicated that no items were seen as distinct in terms of both

type and goal. Of these 15 items, 8 items were seen as indistinct in terms of type, and 14 were seen as indistinct in terms of goal. Data analysis for personality enhancement items indicated that 8 out of 21 items were seen as indistinct in terms of goal or type, leaving only 13 distinct items. See Appendix C for representativeness ratings.

Conclusions

The results of Pilot Study Two provided a clear basis by which to screen out items that participants did not conceive of as distinct in terms of the goal or type of intervention. More specifically, the data indicate that when categorizing possible applications of germline engineering according to the type and goal of the procedure, participants saw a clear distinction between procedures with a therapeutic goal and procedures with an enhancing goal. In terms of the type of procedure, representativeness ratings indicated that participants saw a clear distinction between procedures targeting physical and non-physical traits. However, the categorical distinction dividing procedures targeting non-physical traits into cognitive and personality traits did not hold up; for many non-physical targets, participants saw little difference between traits associated with cognition and traits associated with personality. We therefore collapsed across these two categories to create a broader category encompassing psychological traits. The final results of the screening procedure employed in this study left us with 60 items divided into 4 groups of 15 items representing physical therapies, psychological therapies, physical enhancements, and psychological enhancements. These items were used in Study One to measure and compare attitudes toward germline engineering and individual differences associated with these attitudes.

We had originally hypothesized that participants would profess highest approval for procedures targeting physical traits, lower approval for procedures targeting cognitive traits, and lowest approval for procedures targeting personality traits. Because the results of Pilot Study Two made it necessary to collapse across two of our three type categories, it was also necessary to modify this hypothesis accordingly. We therefore hypothesized that in Study One, participants would indicate higher approval for procedures targeting physical traits than for procedures targeting psychological traits. In order to test this prediction, we will use a 2x2 analysis of variance instead of a 2x3 analysis of variance. Our other hypotheses regarding differences in approval based on the goal of the procedure as well as the relationship between general approval and individual differences remained unchanged. The purpose of Study One is to compare approval for possible targets of germline engineering according to the goal (therapeutic or enhancement) and type (physical or psychological) of intervention, and to examine the role of several individual difference variables as predictors of overall attitudes.

Chapter 6 – Study One

Participants

Two hundred participants were recruited from the participant pool for Introductory Psychology at Queen's University. Data for 10 of these participants were dropped from all analyses because of incomplete and invalid data. The remaining group of 190 participants consisted of 158 females and 32 males. The mean age of the participants was 18.32 years with a standard deviation of 1.03 years (N=189).

In terms of race or ethnicity, 164 participants self-identified white / Caucasian, 16 were Asian, 7 reported a mixed background, and 3 were black / African Canadian.

Mean family income was between $80,000 and $99,999; however, the modal family income was over $140,000 (N=61).

Materials

All materials were collected online using SurveyMonkey. Participants read a letter of information and provided consent and basic demographic information. From here, participants were presented with several questionnaires. In the order presented, these were: approval ratings for 60 applications of germline engineering, measures of related knowledge, psychological essentialism, perceived risk, and the NEO-FFI personality inventory.

Attitudes Toward Germline Engineering Questionnaire. This questionnaire was made up of 60 items representing possible targets of germline engineering. These items were derived from the screening procedures described in Pilot Study One and Pilot Study Two. Participants were asked to imagine that they, along with a hypothetical partner, were in the very early stages of conception. Using a 7-point Likert-style scale, participants were asked to indicate how likely they would be to use germline engineering to attempt to modify various traits of their unborn child. The 60 items were randomized in terms of type and goal associations, and were presented in the same order to all participants.

Knowledge. Related knowledge was measured with four self-report questionnaire items. The first three of these items used a common stem ("Compared to other undergraduate students, please choose the rating that you think best represents your understanding of:") to assess knowledge of general scientific concepts, biology, and genetic engineering. These items used a 7-point Likert-type scale ranging from "very

poor" to "excellent." These first three items were averaged to create an index of self-rated knowledge of related scientific concepts. The mean score for this knowledge index was 3.93 (N=188).

The fourth item asked participants to indicate the number of credits they had attained in biology, physics, chemistry, and other sciences in both high school and university. Thus there were eight sub-items within this measure, all of which were to be averaged and used as a second index of related knowledge based on objective numbers of related classes taken. The setup of these questions was apparently quite confusing, though, with each of the 8 sub-items missing anywhere between 13 and 64 values, with a mean missing value of 42.25. This indicated that a sizeable portion of our data could not be used. Therefore, no average was computed and this component of the related knowledge measure was dropped from subsequent analyses.

Psychological Essentialism. A measure of psychological essentialism was adapted from Haslam, Rothschild & Ernst's nine-item measure of essentialist beliefs about social categories (2000). The original items used by Haslam et al. (2000) focused on essentialist thinking related to domains such as age, gender, occupation, personality, and sexual orientation. The adapted items gauged participants' beliefs about the degree to which members of the human race itself share a fixed, biologically-based, intrinsic essence. Example items include "Being human is unchangeable; humans cannot become non-humans," and "There are specific features or characteristics that are necessary to be human." Respondents answered these items using a 7-point Likert-type scale with responses ranging from "strongly disagree" to "neither agree nor disagree," to "strongly

agree." See Appendix D for a list of the nine original essentialism items used by Haslam et al. (2000) as well as our nine adapted items.

In their analysis, Haslam et al. (2000) used a varimax-rotated principal components analysis to find a two-factor solution with five items (discreteness, naturalness, immutability, stability, and necessity) comprising the first factor ("naturalness") and four items (uniformity, informativeness, inherence, and exclusivity) comprising the second factor ("reification"); factor loadings ranged from .73 to .91, with a mean of .84. Applying the same procedure to our adapted items returned a two-factor solution with four of the same five items in the first factor grouping together (discreteness, naturalness, immutability, and necessity), and the remaining items (stability, uniformity, informativeness, inherence, and exclusivity) grouping together in the second factor; factor loadings ranged from .49 to .82, with a mean of .63. On the seven-point scale, the mean essentialism score for the total scale with nine items was 4.68 and Cronbach's alpha was .73 (N=186).

Perceived Risk. Risk was measured using three self-report items asking participants to estimate how much risk they imagined germline engineering poses for their child, their future grandchildren, and future generations in general. These items used a 7-point Likert-type scale with responses ranging "little or no risk" to "average risk" to "a great deal of risk." These three items were averaged to create a mean index of perceived risk; the mean score was 4.81 (*SD* = 1.34, N=188). Cronbach's alpha for these three items was .87.

Personality (NEO-FFI). Personality was measured using the NEO-Five Factor Inventory (NEO-FFI) (Costa & McCrae, 1989). The NEO-FFI was designed as an

abbreviated 60-item version of the 240-item Revised NEO Personality Inventory (Costa & McCrae, 1985). Internal consistency for the NEO-FFI scales was calculated using coefficient alpha. Coefficients were .86, .83, .73, .82, and .84 for Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, respectively. These values are consistent with alpha coefficients reported by Costa and McCrae (1989) as well as with values reported by Holden & Fekken (1994) in a sample of Canadian university students. Mean scores for each scale were also consistent with past norms (Costa & McCrae, 1989).

Procedure

Participants were recruited through the participant pool for introductory psychology at Queen's University and were offered course credit for their participation. All sections of this experiment were conducted online using SurveyMonkey, a site that allows users to create web-based surveys. After reading a letter of information and giving consent, participants provided basic demographic information, and then completed, in order, questionnaires on attitudes toward germline engineering, related knowledge, psychological essentialism, perceived risk, and personality. The order of questionnaires was consistent for all participants.

Chapter 7 – Study One Results

Psychometric Data

With the NEO-Five Factor Inventory, primary analysis of means and standard deviations for Neuroticism ($X = 2.12$, $SD = .57$), Extraversion ($X = 1.48$, $SD = .55$), Openness ($X = 1.58$, $SD = .50$), Agreeableness ($X = 1.35$, $SD = .53$), and Conscientiousness ($X = 1.39$, $SD = .52$) revealed that these scores were consistent with

past research. These scores are based on a Likert-type scale with values ranging from 0 to 4.

Hypotheses: Approval of Human Germline Engineering

Our first hypotheses focused on approval for human germline engineering according to the goal and type of application. With respect to goal, we hypothesized that approval would be higher for applications with a therapeutic goal than for applications with an enhancement goal. With respect to type, our modified hypothesis was that approval would be higher for applications that target physical traits than for applications that target psychological traits. Mean approval ratings are presented in Table 2.

Table 2

Mean Approval Ratings from Study One.

Target / Group

	Mean	SD	N	Alpha	Items
Overall approval	3.87	1.32	190	.984	60
Approval for Physical Therapies	5.25	1.50	190	.970	15
Approval for Psychological Therapies	4.46	1.46	190	.955	15
Approval for Physical Enhancements	2.86	1.48	190	.964	15
Approval for Psychological Enhancements	2.92	1.57	190	.974	15
Approval for Modifying Physical Traits	4.04	1.29	190	.965	30
Approval for Modifying Psychological Traits	3.68	1.37	190	.969	30
Approval for Modifying Therapeutic Goals	4.84	1.44	190	.977	30
Approval for Modifying Enhancement Goals	2.88	1.50	190	.982	30

We conducted an analysis of variance to test the hypothesis that approval would be higher for therapeutic versus enhancement goals and for physical versus psychological types. Our analysis of variance found a main effect of goal, $F(1, 189) = 425.77$, $p < .001$, and a main effect of type, $F(1, 189) = 147.91$, $p < .001$. The interaction between goal and type was also significant, $F(1, 189) = 224.68$, $p < .001$. This indicated that the main effect of type was driven by the difference in approval scores for therapeutic procedures, and not enhancement procedures; approval differed greatly between physical therapies and psychological therapies, but was nearly identical for physical enhancements and psychological enhancements. Pairwise comparisons showed that approval for applications with therapeutic goals was higher than approval for applications with enhancement goals, $p < .001$. Pairwise comparisons also showed that approval was higher for applications targeting physical traits versus applications targeting psychological traits, $p < .001$. These results confirmed our hypotheses concerning approval based on goal and type of trait targeted.

Hypotheses: Individual Differences

Our next set of hypotheses was based on the relationship between overall approval and specific individual differences. We hypothesized that approval would have a positive relationship with higher levels of related knowledge and Big Five Openness, and a negative relationship with perceived risk, female gender and psychological essentialism.

We conducted a multiple linear regression analysis in order to test these hypotheses. The overall model proved significant, $F(9, 173) = 6.10$, $p < .001$, $R^2 = .24$.

The results of this regression on overall approval are presented in Table 3. Note that with gender, females were coded as a "one" and males as a "two."

Table 3.

Multiple Regression analysis for overall approval from Study One.

	Standardized β	t
Gender	.18*	2.48
Knowledge	.15*	2.15
Perceived Risk	-.32***	-4.59
Essentialism	.11	1.56
Neuroticism	-.14	-1.78
Extraversion	-.13	-1.66
Openness	-.05	-.72
Agreeableness	.17*	2.11
Conscientiousness	-.03	-.34

Note: *$p < .05$, **$p < .01$, ***$p < .001$

Several of our hypothesized predictors of overall approval were significant: gender, knowledge, and perceived risks all had significant individual effect. An independent samples t-test comparing overall approval by gender showed that women were significantly less approving than men.

Contrary to our predictions, psychological essentialism and Big Five Openness were non-significant. Unexpectedly, several other personality factors were at or near significance: Agreeableness was a significant predictor of overall approval, with

Neuroticism (β = -.14, p = .08) and Extraversion (β = -.13, p = .10) showing weak effects.

We conducted four other multiple linear regression analyses to examine the relationship between individual differences and approval for germline engineering procedures according to type and goal. For procedures with a therapeutic goal and physical type, our model proved significant, $F(9, 173) = 3.76$, $p < .001$, $R^2 = .16$. Again, several of our predictor variables proved significant: gender (β = .16, p = .04), knowledge (β = .15, p = .05), perceived risk (β = -.24, p = .002), and Big Five Openness (β = -.18, p = .02), all proved significant. Psychological Essentialism was close to significance (β = .13, p = .06), and the other Big Five factors were not significant. See Table 4 for details.

Table 4.

Multiple Regression Analysis for Approval for Physical Therapies from Study One

	Standardized β	t
Gender	.16*	2.10
Knowledge	.15*	2.02
Perceived Risk	-.24**	-3.22
Essentialism	.13	1.90
Neuroticism	-.08	-.98
Extraversion	-.06	-.77
Openness	-.18	-2.44
Agreeableness	.06*	.74
Conscientiousness	-.03	-.44

Note: *$p < .05$, **$p < .01$, ***$p < .001$

For germline engineering procedures categorized as psychological therapies, our model proved significant, $F(9, 173) = 3.25$, $p = .001$, $R^2 = .15$. For this model, only gender ($\beta = .16$, $p = .04$) and perceived risk ($\beta = -.24$, $p = .001$) were significant predictors of approval. Psychological essentialism was nearly significant ($\beta = .14$, $p = .06$); knowledge ($\beta = .11$, $p = .15$) and Openness ($\beta = -.11$, $p = .16$) were weakly related to approval. See Table 5 for details.

Table 5

Multiple Regression Analysis for Approval for Psychological Therapies from Study One

	Standardized β	t
Gender	.16*	2.07
Knowledge	.11	1.46
Perceived Risk	-.24**	-3.25
Essentialism	.14	1.92
Neuroticism	-.09	-1.14
Extraversion	-.08	-.96
Openness	-.11	-1.46
Agreeableness	.09*	1.13
Conscientiousness	-.04	-.47

Note: *$p < .05$, **$p < .01$, ***$p < .001$

For procedures categorized as physical enhancements, our model proved significant, $F(9, 173) = 7.60$, $p < .001$, $R^2 = .28$. Gender ($\beta = .14$, $p = .04$), knowledge

(β = .15, p = .03), and risk (β = -.34, p < .001), were significant predictors, along with Neuroticism (β = -.15, p = .05), Extraversion (β = -.16, p = .03), and Agreeableness (β = .23, p = .003). Psychological essentialism was non-significant, (β = .06, p = .33), as was Openness (β = .03, p = .69). See Table 6 for details.

Table 6.

Multiple regression analysis for approval for Physical Enhancements from Study One

	Standardized β	t
Gender	.14*	2.10
Knowledge	.15*	2.18
Perceived Risk	-.34***	-5.05
Essentialism	.06	.97
Neuroticism	-.15*	-1.99
Extraversion	-.16*	-2.14
Openness	.03	.40
Agreeableness	.23**	3.00
Conscientiousness	-.01	-.20

Note: *p < .05, **p < .01, ***p < .001

For psychological enhancements, our model was again significant, F(9, 173) = 6.42, p < .001, R^2 = .25. Gender (β = .16, p = .02) and risk (β = -.31, p < .001) were significant predictors, along with Neuroticism (β = -.16, p = .04) and Agreeableness (β = .20, p = .01). Related knowledge (β= .13, p = .08) and Extraversion (β= -.15, p = .06)

were nearly significant. Psychological essentialism ($\beta = .04$, $p = .57$) and Openness ($\beta = .08$, $p = .28$) were not significant. See Table 7 for details.

Table 7.

Multiple regression analysis for approval for Psychological Enhancements from Study One

	Standardized β	t
Gender	.16*	2.32
Knowledge	.13	1.78
Perceived Risk	-.31***	-4.41
Essentialism	.04	.57
Neuroticism	-.16*	-2.09
Extraversion	-.15	-1.94
Openness	.08	1.08
Agreeableness	.20*	2.52
Conscientiousness	.00	-.04

Note: *$p < .05$, **$p < .01$, ***$p < .001$

Conclusions

The results of Study One show that approval for human germline engineering procedures is dependent on the goal of the procedure and the type of trait that is targeted. With respect to goals, approval is higher for procedures with a therapeutic goal than for procedures with an enhancement goal. As for the type of trait, we found that approval is

higher for procedures targeting physical traits than for procedures targeting psychological traits. These findings offer strong support for our first set of research hypotheses.

The main finding of our regression analyses is that gender, related knowledge, and perceived risk are the best predictors of attitudes toward germline engineering. All three of these variables were significant predictors of overall attitudes toward germline engineering, as well as attitudes toward physical therapy procedures and physical enhancement procedures; gender and perceived risk, but not related knowledge, were significant predictors of attitudes toward psychological therapies and psychological enhancements. More specifically, women showed lower approval than men for all procedures as an aggregate as well as for procedures sorted according to goal and type. There was a consistent negative relationship between perceived risk and all forms of approval, indicating that approval declined when perceived risk was higher. For related knowledge, the data show that approval increases with higher levels of related knowledge. These data show that approval for human germline engineering is lower among women than men, lower for persons who perceive associated risks to be higher, but higher among those with more related knowledge.

There was less support for the ideas that psychological essentialism or Big Five Openness might predict approval of germline engineering. Our adapted measure of psychological essentialism was not a significant predictor of overall approval or approval according to goal or type. Openness was not a significant predictor of overall approval, but it is worth noting that it did predict attitudes for procedures classified as physical therapies. Of related interest is the unexpected finding that several other Big Five factors were significant predictors of attitudes toward procedures classified as physical

enhancements or psychological enhancements: approval for physical enhancements was negatively related to Neuroticism and Extraversion, and positively related to Agreeableness, while approval for psychological enhancements was negatively related to Neuroticism and positively related to Agreeableness.

Chapter 8 – General Discussion

Human genetic engineering is an important and controversial new domain of medical science that may potentially allow parents to modify the phenotype of their unborn children. Of course, germline engineering is a nascent field that still faces significant technical limitations. Although new genetic discoveries are continually appearing in the popular media and scientific literature, manipulating the human genome in order avoid the unwanted or enhance the desirable is technically difficult. However, this does not detract from the value of understanding our own attitudes toward germline engineering. Pundits and professionals alike weighed in on related medical technologies like cloning and in-vitro fertilization before these were even available, and advocates and opponents of human germline engineering have been debating the ethical aspects of this technology for some time (Wilson & Haslam, 2009). A scientifically valid survey of attitudes toward germline engineering represents an opportunity to explore the opinions of non-experts and to relate these attitudes to individual differences.

Results of Pilot Studies

Our first Pilot Study allowed us to refine our initial item pool of potential targets of germline engineering on the basis of participant familiarity ratings. A total of 54 unfamiliar items were removed from a pool of 170 targets. In our second Pilot Study, we asked our participants to rate the remaining 116 items in terms of how representative they

felt each target was of the goals (therapeutic or enhancing) and types (physical, cognitive, or personality) of germline engineering. These ratings were intended to provide us with a means of confirming whether or not our participants categorized the items in the same way that we did. The results allowed us to delete items that were indifferently representative of specific goal and type categorizations. They also showed that for many items we had thought of as cognitive therapies or enhancements, or personality therapies or enhancements, our participants did not have a distinct association with any specific goal or type of trait. This reflected a breakdown, in the eyes of our participants, of the distinction between either or both categorizations and led us to collapse our cognitive and personality categories to include the remaining distinctly-categorized items under the new labels of "psychological therapies" and "psychological enhancements."

The cause of this breakdown is unclear. We know from the results of Pilot Study One that participants could be expected to be familiar enough with the given targets of germline engineering. It is possible that not all participants had a comfortable understanding of the difference between "cognitive traits" and "personality traits." Participants were presented with thorough explanations of germline engineering as well as therapeutic goals and enhancement goals, but we avoided including a detailed definition of "cognitive traits" and "personality traits" in order to avoid the chance that our representativeness ratings would be unfairly influenced by such definitions. It is also possible that for many psychological characteristics, laypeople simply do not see a strong distinction between cognitive and personality associations. We had assumed that this distinction would hold up in part because of the conclusions drawn by Riis et al. (2008) with regards to preferences for enhancement pharmaceuticals. But these authors did not

validate participants' associations between characteristics and categories, possibly because they were more concerned about the relationship between acceptance of modification and the degree to which modified traits were thought of as fundamental to self-identity. At a more specific level, it is possible that the items conceived of as cognitive or personality therapies that were screened out based on indistinct goal ratings indicate that these characteristics, while nominally undesirable, are actually seen part of the normal range of human experience and behaviour. In any case, if participant representativeness ratings indicate that procedures to screen out these characteristics are equally therapeutic and enhancing, then the results do not necessarily indicate a "breakdown" per se, but a valid screening procedure for items that would otherwise be inappropriate to compare. At this point it is difficult to draw more definitive conclusions without further studies.

We were thus left with four groups of 15 items that were seen as distinctly representative of physical therapies, psychological therapies, physical enhancements, and psychological enhancements. We modified our type-relevant hypothesis so that modifications to physical traits were expected to have higher approval than modifications to psychological traits. Our remaining goal-relevant hypothesis and our hypotheses concerning the directional influence of various individual differences on approval remained unchanged.

Results of Study One – Type and Goal

The results of Study One confirmed our goal and type hypotheses by showing that approval was higher for therapies than enhancements, and for procedures targeting physical traits than for those targeting psychological traits. The finding that participants

approved more of therapeutic procedures than enhancing procedures is interesting because it echoes the findings of earlier attitude research on basic genetic engineering in agriculture and medicine (Chen & Raffan, 1999; Hampel, et al., 2000; Meisenberg, 2009; Meister, et al., 2005). This shows that just as we approve more of genetically modifying crops for disease resistance than for enhanced growth (Chen & Raffan, 1999) and of pre-implantation genetic diagnosis for preventative reasons but not enhancements (Meister et al., 2005), we also approve of germline engineering procedures that are therapeutic more than those that are enhancing. This may reflect an underlying sense of ethical concern that removing genetic diseases and disadvantages is fair because it creates a level playing field, whereas adding desirable characteristics is unfair because it gives an individual advantages over others. Another possibility is that genetic enhancements are seen as a degradation of our human nature. This interpretation makes sense in the context of arguments from critics who argue that modification represents a fundamental loss of that which makes us human (see Arnhart, 2003; Wilson & Haslam, 2009). In any case, this novel finding fits within the context of attitudes toward other forms of genetic engineering and confirms our first hypothesis.

Our other hypothesis concerning the basic structure of attitudes was that approval would be higher for procedures targeting physical traits than for those targeting psychological traits. Because there is no existing research that looks at the possibility of attitude variation according to the type of trait targeted for genetic modification, we based this hypothesis on findings in the pharmacological enhancement literature that found a predilection for the use of drugs taken with the intent of enhancing cognitive abilities or emotional traits (Jefferson, 1996; McCabe et al., 2005; Yesavage et al., 2002) and,

specifically, a preference for enhancing cognitive traits more than social and emotional traits (Riis, et al., 2008). We used an analysis of variance to find that approval differed according to the type of trait targeted for modification, and pairwise comparisons confirmed our hypothesis that approval was higher for modifications targeting physical traits than those targeting psychological traits.

This is an interesting finding because even though our hypothesis was drawn from somewhat disparate areas of research, we see that there is a stable underlying structure of attitudes toward self-modification using either drugs or germline engineering such that we approve of physical modifications more than psychological modifications independent of the goal of the modification. It is possible that this structure of attitudes is related to the idea that physical traits are inherently less fundamental to our self-identity than psychological traits. Such was the reason given by participants in Riis et al.'s (2008) study for the difference in attitudes toward cognitive and personality modifications using drugs. It would be interesting for future research to include a measure of the degree to which participants associate a given target of germline engineering as fundamental to self-identity and to relate this variable to attitudes in order to determine whether this predictor may account for attitude differences.

Results of Study One – Individual Differences

Our next group of hypotheses concerned the role of various individual differences as predictors of attitudes toward germline engineering. As predicted, we found that overall attitudes were predicted by gender, related knowledge, and perceived risk. Contrary to our predictions, psychological essentialism and Big Five Openness had only weak roles as predictors. We will attempt to account for each of these findings in turn.

Results of Study One – The Role of Gender

Gender was a significant predictor of overall attitudes toward germline engineering as well as attitudes toward all four subsets of procedures (physical therapies, psychological therapies, physical enhancements, and psychological enhancements). We found that, on average, women expressed lower approval for germline engineering than did men. This is an important finding because it replicates a consistent pattern of findings in the genetic engineering literature (Chen & Raffan, 1999; Hampel, et al., 2000; Lock & Miles, 1993; Prokop et al., 2007). A possible reason for this trend is that women are more skeptical in their judgments of genetic engineering (Hampel et al., 2000) or may approach the technology with more concerns than do males (Prokop et al., 2007). In the science education literature, some researchers have argued that women are generally less interested than men in science (Miller, Blessing, & Schwartz, 2006). This complementary explanation may also underlie the observed pattern of lower approval in women in our sample. There is also the possibility that women are more tentative toward germline engineering for the same reason that they are more tentative toward genetically engineered food, namely that they are usually the purchasers and providers of food and this position of responsibility necessitates greater caution, leading to lower approval (Hill, Stanisstreet, Boyes, O'Sullivan, 1998; Moerbeek & Casimir, 2005). This finding has been referred to as the "gender paradox" (Moerbeek & Casimir, 2005) and it represents an interesting possible explanation for our findings. It is possible that the idea of germline engineering heightens a sense of responsibility in women because women have always been the traditional caregivers for children and, despite changes in modern social roles, may still feel a stronger sense of connection or responsibility towards their

children than do men. In any case, caution should be exercised in interpreting these results because of the relative disparity in the numbers of females and males in this study, as well as the fact that this is a new area of study with few points of reference or comparison.

Results of Study One – The Role of Perceived Risk

Perceived risk was another strong predictor of attitudes in general and of our four subsets of procedures sorted by goal and type. Our findings indicate that approval declines as a function of perceived risk: the greater the perception of risk, the lower the approval. We hypothesized that risk would play an important role even though it was difficult to find studies that had examined the role of perceived risk as a predictor of attitudes toward genetic engineering. The only study to do so (Urban & Pfenning, 2000) found that, of the predictors included, risk perception was the most important determinant of attitudes toward genetic engineering. Many writers in the bioethics community emphasize the possibility of unforeseen genetic risks to one's future generations, as well as the wider risk to society that consumer- and competition-driven genetic engineering may pose (Fukuyama, 2002; McKibben, 2004; Sandel, 2007). In our regression analysis, perceived risk was found to have the strongest weighting of any individual difference predictor, as well as the strongest degree of significance. These results therefore extend similar findings from the domain of general genetic engineering (Urban & Pfenning, 2000) to the domain of germline engineering. Because our measure was created as an aggregate of perceived risk to one's child, grandchildren, and future generations, we cannot speculate on which single aspect of perceived risk, if any, plays a stronger or weaker role as a determinant of attitudes toward germline engineering.

It is interesting to note that across the four subsets of modifications, perceived risk was a better predictor of attitudes toward the items with the lowest mean approval scores. We found that risk had a stronger role as a determinant of attitudes toward physical enhancements and psychological enhancements, which had average approval scores of 2.86 and 2.92, respectively, than of attitudes toward physical therapies and psychological therapies, which had average approval scores of 5.25 and 4.46, respectively. It is important to point out that the standard deviations in approval for these four subsets of items are all very similar, ranging from 1.46 to 1.57, indicating that we can therefore make comparisons across these subsets without being concerned with differences in the ranges of approval scores. These findings suggest that while risk plays a strong role in determining attitudes toward both genetic therapies and enhancements, it seems to play a stronger role in cases that involve attempts to confer some genetic advantage in order to enhance and improve beyond the norm.

Results of Study One – The Role of Related Knowledge

Related knowledge was a significant predictor of overall approval, and of approval for physical therapies and enhancements, but not of psychological therapies and enhancements. The finding that knowledge of science plays a strong role as a predictor of general attitudes is similar to the results of other studies that have found knowledge of general science or biology to predict attitudes toward genetic engineering (Chen & Raffan, 1999; Sturgis, et al., 2005; Surmeli & Sahin, 2010), as well as studies that found knowledge of genetics and biotechnology to predict support for non-human genetic engineering (Allum, et al., 2008; Bal, et al., 2007; Hampel, Pfenning, & Peters, 2000; Klop & Severiens, 2007). This is an interesting pattern of findings because it suggests

that with more time spent formally studying science, and specifically biology and genetics, comes a higher likelihood of support for human genetic engineering.

Our measure of knowledge was an aggregate based on self-reported knowledge of general science, biology, and genetic engineering. We had hoped to include in our aggregate an index of the number of related science courses in high school and university, but the format of our response options seemed to confuse our participants and we were forced to drop this part of the measure from our aggregate due to missing data. Our knowledge measure is therefore broad measure of related knowledge that is dependent on the accuracy of our participants' responses. The fact that this measure predicts support for germline engineering may be seen as support for earlier research that demonstrated a relationship with related scientific knowledge and attitudes toward genetic engineering. Future research could compliment this finding by drawing from a pool of participants with knowledge of genetics in order to see if more relevant knowledge acts as a stronger predictor of support.

Results of Study One – The Role of Psychological Essentialism

Our measure of psychological essentialism was adapted from Haslam et al.'s (2000) scale designed to measure essentialist thinking in social categories. A factor analysis of our items indicated that we had replicated the two-factor structure found by the original authors fairly well, indicating that we had successfully adapted the items to deal with essentialism of the human species. We did not examine the impact of considering both factors separately, because this was not how the measure was initially used by Haslam, et al. (2000). That being said, it was somewhat surprising to see that essentialism did not predict approval of germline engineering as hypothesized. It is

possible that while the items were successfully adapted to measure a different form of essentialist thinking, this particular form simply does not relate to attitudes toward germline engineering. It is curious that for two subsets of procedures, physical therapies and psychological therapies, essentialism was trending towards significance at .06, but with attitudes toward physical enhancements and psychological enhancements essentialism was quite far from significance. These findings are difficult to interpret given that a pattern almost emerged with two of the four subsets of modifications, but not quite at a level of significance, and not so at all for overall approval.

Results of Study One – The Role of Personality

We decided to include a measure of personality as a possible predictor of attitudes toward germline engineering because we had reason to expect that specific facets of Openness to experience such as a preference for novelty, independence, and non-traditional values (Ashton et al., 2000; De Raad et al., 1992) would cause the factor to correlate with attitudes toward germline engineering. Also, we could find no previous studies that had looked at personality factors as predictors of attitudes toward even basic genetic engineering, and so there was motivation to examine an unexplored potential relationship. The results of Study One indicated that Big Five Openness was not a significant predictor of overall attitudes toward germline engineering, nor of attitudes toward any subset of modifications. These findings lead us to conclude that one's degree of Openness does not necessarily relate to being open-minded toward germline engineering. It is worth considering that while certain facets of Openness such as an appreciation for unusual ideas may seem to relate to new technologies such as germline engineering, there are other facets such as appreciation for art, wide-ranging interests,

introspection and imagination (McCrae & John, 1992) which would not necessarily relate to such attitudes. We must also consider that an appreciation for a new or unconventional idea does not necessarily imply support for that idea.

There were some unexpected results of including factors from the NEO-Five Factor Inventory in our analysis. The first is that higher levels of Agreeableness predicted higher overall approval. Agreeableness was the only factor of the five that was a significant predictor of overall approval. This suggests that part of what drives interest and approval is may be mere cooperativeness and trust. Agreeable people are also likely to be more optimistic (McCrae & John, 1992), and this optimism may make such people more hopeful and confident about the possible benefits of germline engineering while downplaying negative aspects like perceived risk and moral uncertainty.

A closer examination of the relationship between Big Five factors and the four subsets of modifications sorted by goal and type of intervention reveals that Agreeableness is the only factor that predicts attitudes toward physical therapies. No factors predict attitudes toward psychological therapies. However, we found that several personality factors predicted attitudes toward modifications considered to have enhancement goals. For physical enhancements, Neuroticism and Extraversion showed an inverse relationship with approval, and Agreeableness showed a positive relationship. This indicates that approval for physical enhancement is likely to be somewhat higher among those with lower Neuroticism, lower Extraversion (i.e. introverts) and higher Agreeableness. A similar pattern was observed with attitudes toward psychological enhancements, where Neuroticism and Extraversion showed a negative relationship with

approval, and Agreeableness showed a positive relationship, again indicating higher approval among Introverts, Agreeable people, and those low in Neuroticism.

These were unexpected findings and, like our comments concerning the relationship with Agreeableness and overall approval, our interpretation is speculative. The first thing to notice is that personality does not have a strong relationship with approval for physical therapies and psychological therapies, which are generally seen quite favourably; however, personality factors do play a significant role in predicting approval of physical enhancements and psychological enhancements, which are seen relatively unfavourably. This shows that there are probably no specific personality factors that distinguish someone who approves of germline procedures to correct impairments of function that put an individual below what is species-typical, but that a person who approves of procedures that aim to enhance one's body or mind is likely distinguishable by lower Neuroticism and Extraversion, and higher Agreeableness.

Looking at each of these relationships in turn, it is possible that with Neuroticism, approval for contentious germline enhancements depends to some degree on lower levels of anxiety and guilt, since the goal of these procedures are often associated with threats to social justice (Fukuyama, 2002; McKibben, 2004; Sandel, 2007). This would lead us to believe that someone untroubled by neurotic concerns is more likely to approve of enhancements. The negative relationship with Extraversion is more difficult to interpret. It is possible to find reasons why both extraverts and introverts might be more likely to approve of germline engineering procedures with an enhancement goal, and such speculations are of course confounded by hindsight bias. For example, it seems possible that extraverts would be more approving here because of a desire to enhance

characteristics that facilitate one's pre-existing tendency to engage with the external world, such as greater physical energy, decreased ageing, or better social skills. Conversely, it also seems possible that introverts might want to facilitate deeper engagement with the external world by enhancing the same characteristics. At the same time, we might speculate that introverts would respond to specific enhancement items such as greater concentration, memory, or intelligence that facilitate a connection with more internal mental states. Without a thorough exploratory analysis, it remains difficult to speculate on the negative relationship between extraversion-introversion and approval for enhancement forms of germline engineering. Lastly, with Agreeableness the most consonant analysis seems to be that specific elements of Agreeableness such as optimism, trust, warmth, and lack of suspiciousness (McCrae & John, 1992) would create a tendency to agree with even the more contentious forms of germline engineering. However, it is interesting to note that Agreeableness is also based on a desire for social harmony (McCrae & John, 1992) and it is therefore somewhat ironic that more agreeable people are likely to approve of forms of germline engineering that are believed would pose a threat to social justice (Fukuyama, 2002; McKibben, 2004; Sandel, 2007). While unexpected, these findings are interesting to examine and may suggest avenues for future work that seeks to examine the relationship between personality factors and approval of extreme or unaccepted forms of human germline engineering.

Limitations and Future Directions of this Research

It must be noted that this series of studies has some limitations. First, our samples were drawn from a university population and so many of our participants are very similar in terms of age and background. Because we used a participant pool of introductory

psychology students, most participants are very young, as indicated by the mean ages in our studies. A great majority of our sample is of Caucasian background and family income is also higher than average. These samples are therefore comparable to those used in many other psychology studies and although representative of the Queen's population in general, are not representative of the greater population. Future work in this area would benefit from using a sample drawn from the greater population because this would offer a point of comparison and contrast.

Another area of concern is the breakdown in differentiation between targets of modification associated with cognition and personality. For many potential targets of germline engineering presented in Pilot Study Two, participant representativeness ratings indicated a perceived breakdown in the distinctions between therapeutic and enhancing goals and between cognitive and personality traits. This may reflect the fact that for the average person it is truly difficult to drawn distinctions between cognition and personality in many cases. Another possibility is that it may represent a lack of understanding as to the precise definition of cognition on the part of our participants.

Conclusions

This research contributes to a growing body of work that investigates attitudes toward genetic engineering and human modification. While a moderate amount of research has looked at attitudes toward genetic engineering, most of this work looks at procedures targeting agriculture and animals, making our study one of very few to explore attitudes toward forms of human genetic modification. Furthermore, no studies that we are aware of have looked specifically at germline modification and so our findings represent an important contribution to this area of research. Although the

practice of germline engineering has not developed at the same rate as the theories behind it, pre-eminent voices in the field argue that it is only a matter of time before the technology catches up to the demand that is already here. Given this level of interest among those in-the-know, as well as the passionate opinions that this topic engenders in those who are unfamiliar with it, we believe this research provides new and important information on attitudes toward germline engineering. Future research in this area would benefit by attempting to incorporate these findings into a more comprehensive framework of views concerning human nature and self-identity, as well as attitudes toward genetically engineered medical therapies and enhancements.

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Appendix A – Pilot Study One familiarity ratings

Physical Therapy Items	Mean Familiarity Rating
Cancer	5.42
Diabetes	5.22
Asthma	5.16
Cystic fibrosis	5.05
Deafness	5.00
Moles and birthmarks	4.92
Blindness	4.90
Heart disease	4.87
Baldness and hair loss	4.84
High blood pressure	4.76
High cholesterol	4.60
Red-green colour blindness	4.55
Genetic sleep disorders	4.41
Facial asymmetries	4.35
Leukemia	4.34
Genetic predisposition to obesity	4.27
Thyroid disease	4.21
Parkinson's disease	4.18
Genetic predisposition to allergies	4.05
Osteoporosis	4.00
Autoimmune disorders	3.92
Developmental co-ordination disorders	3.79
Multiple sclerosis	3.68
Genetic fertility problems	3.62
Hemophilia	3.61
Genetic disorders*	3.58
Sickle cell anemia*	3.36
Crohn's disease*	3.28
Tic disorders*	3.26
Muscular dystrophy*	3.26
Heritable disorders of connective tissue**	3.03
Metabolic syndrome**	2.92
Genetically heritable metabolic disorders**	2.60
Familial emphysema**	2.51
Hermaphroditism**	2.43
Huntington's chorea**	2.30
Tay-Sachs disease**	2.26
Ulcerative colitis**	2.21
Mean	3.92
Standard Deviation	0.93
Cut point	2.99

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Cognitive Therapy Items	Mean Familiarity Rating
Homosexuality	5.27
Autism	5.19
Alzheimer's	4.92
ADD / ADHD	4.84
Down syndrome	4.81
Communication disorders	4.46
Schizophrenia	4.26
Low IQ	4.24
Mental retardation	4.08
Language learning disabilities	4.05
Learning disabilities associated with motor skills	4.03
Age-related cognitive decline	3.97
General memory deficits	3.97
Developmental delays	3.90
Learning disabilities associated with memory	3.84
Math learning disabilities*	3.82
Low mathematical intelligence*	3.82
Dementia*	3.79
Asperger syndrome*	3.66
Information processing deficits**	3.38
Low verbal intelligence**	3.00
Pervasive developmental disorders**	2.60
Average	4.09
SD	0.66
Cut point	3.43

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Personality Therapy Items	Mean Familiarity Rating
Antisocial behaviour	5.45
Jealousy	5.34
Aggression	5.03
Depression	4.97
Compulsive behaviour	4.81
Phobias or extreme fears	4.73
Obsessive thoughts	4.66
Impulsivity issues	4.66
Suspiciousness and paranoia	4.49
Extreme moodiness	4.45
Social phobias	4.41
Narcissism / vanity	4.37
Proneness to eating disorders	4.32
Bipolar disorders / manic-depressive disorder	4.32
Pessimism	4.31
Extreme shyness*	4.14
Sub-clinical depression / low level depression*	4.13
Neuroticism or high anxiety*	3.92
Predisposition to borderline personality disorder*	3.84
Panic disorders*	3.74
Psychopathy**	3.47
Predisposition to histrionic personality disorder**	2.58

Somatoform disorders**	2.41
Average	4.30
SD	0.73
Cut point	3.57

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Physical Enhancement Items	Mean Familiarity Rating
Gender	6.42
Height	6.00
Eye colour	5.92
Weight	5.90
Handedness	5.84
Hair colour	5.74
Skin tone	5.57
Hand-eye co-ordination	5.54
Athleticism	5.50
Hair thickness	5.41
Physical sense of balance	5.32
Ability to play a musical instrument	5.31
Body type	5.30
Hearing	5.19
Physical reflexes	5.19
Aging	5.05
Facial symmetry	5.00
Agility	4.97
Resistance to tanning / sunburn	4.95
Ability to sing*	4.87
Fertility*	4.87
Immune response *	4.77
Amount of sleep needed*	4.68
Pain tolerance*	4.66
Nightvision**	4.48
Increased lung capacity**	4.40
Visual acuity**	4.37
Perfect pitch**	4.11
Metabolic efficiency**	3.84
Average	5.14
SD	0.58
Cut point	4.56

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Cognitive Enhancement Items	Mean Familiarity Rating
Mental processing speed	5.53
General memory	5.47
Concentration	5.42
Logical thinking	5.41
Musical ability	5.32
Mathematical ability	5.27
Mental problem solving	5.26

Analytical thinking	5.23
Ability to think creatively	5.13
Ability to multitask	5.11
IQ	5.03
Photographic memory	5.03
Intellectual perseverance	4.95
Artistic creativity	4.86
Ability to learn languages	4.66
Mental reaction time	4.66
Ability to play or sing music by ear	4.66
Verbal ability*	4.50
Spatial reasoning*	4.43
Delay of gratification*	4.27
Linguistic expressiveness**	3.65
Childhood cognitive maturation**	3.32
Bodily-kinesthetic intelligence**	3.16
Average	4.75
SD	0.65
Cut point	4.10

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Personality Enhancement Items	Mean Familiarity Rating
Competitiveness	5.76
Sense of humour	5.74
Confidence	5.71
Passion	5.71
Outgoingness	5.70
Self-discipline	5.63
Efficiency	5.57
Compassion	5.57
Friendliness	5.57
Open-mindedness	5.50
Emotionality	5.38
Positive emotion	5.34
Optimism	5.25
Ambition	5.24
Agreeableness	5.18
Shyness	5.16
Sociability	5.16
Capacity for love / commitment	5.14
Conscientiousness	5.11
Sensitivity	5.05
Aggression*	4.98
Security*	4.76
Emotional patience*	4.64
Responsiveness to others' need for care*	4.50
Inventiveness*	4.43
Ingenuity**	3.92
Neuroticism**	3.92
Industriousness**	3.47
Extraversion**	3.22
Altruism**	2.90

Average	4.99
SD	0.77
Cut point	4.22

** denotes an item deleted in the second round of deletions (i.e. because of low mean familiarity score)*
*** denotes an item deleted in the first round of deletions (i.e. because mean familiarity score was one standard deviation below average)*

Appendix B – Items retained for Pilot Study Two based on Pilot Study One familiarity scores

Parkinson's disease
Cystic fibrosis
Multiple sclerosis
Diabetes
Cancer
Developmental co-ordination disorders
High cholesterol
Hemophilia
Red-green colour blindness
Genetic predisposition to obesity
Genetic predisposition to alcoholism
Baldness and hair loss
Heart disease
High blood pressure (Hypertension)
Blindness
Deafness
Autoimmune disorders (e.g. Celiac disease)
Facial asymmetries
Moles and birthmarks
Thyroid disease
Leukemia
Osteoporosis
Genetic sleep disorders (e.g. Sleep apnea)
Genetic predisposition to allergies
Asthma
Genetic fertility problems (e.g. Endometriosis, low sperm count / sperm motility)
Down syndrome
Autism
Alzheimer's
Age-related cognitive decline
Homosexuality
Schizophrenia
Developmental delays
Language learning disabilities
Learning disabilities associated with motor skills (i.e. motor clumsiness)
Learning disabilities associated with memory
General memory deficits
ADD / ADHD Attention-deficit hyperactivity disorder
Low IQ
Mental retardation
Communication disorders
Proneness to eating disorders (e.g. anorexia, bulimia)
Narcissism / vanity
Depression
Phobias or extreme fears
Pessimism
Obsessive thoughts
Compulsive behaviour
Bipolar / Manic-depressive disorder
Social phobias
Impulsivity issues (e.g. in gambling)
Addictive personality

Jealousy
Suspiciousness and paranoia
Antisocial behaviour
Aggression
Extreme moodiness
Height
Weight
Muscle
Facial symmetry
Body type
Hair colour
Eye colour
Aging
Handedness
Hearing
Skin tone
Ability to play a musical instrument
Gender
Hair thickness
Athleticism
Agility
Hand-eye co-ordination
Physical sense of balance
Physical reflexes
Resistance to tanning / sunburn
Physical energy
General memory
IQ
Photographic memory
Concentration
Ability to learn languages
Ability to multitask
Mathematical ability
Mental reaction time
Mental problem solving
Ability to play or sing music by ear
Artistic creativity
Analytical thinking
Logical thinking
Ability to think creatively
Intellectual perseverance
Musical ability
Open-mindedness
Emotionality
Conscientiousness
Self-discipline
Efficiency
Extraversion
Shyness
Outgoingness
Sociability
Positive emotion
Agreeableness
Compassion
Friendliness
Competitiveness

Confidence
Sensitivity
Passion
Optimism
Sense of humour
Capacity for love / commitment
Ambition
Masculinity / femininity

Appendix C – Pilot Study Two representativeness ratings

Physical Therapy Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Genetic predisposition to allergies	4.97	4.39	4.75	2.83	2.43
Multiple sclerosis	5.57	4.19	5.69	3.44	2.78
Asthma	5.58	4.46	5.37	2.63	2.54
Genetic predisposition to alcoholism	5.00	4.22	4.61	4.68	4.64
Diabetes	5.78	4.69	5.83	3.17	2.77
Leukemia	6.09	4.29	5.91	3.35	2.88
Cancer	6.27	4.26	6.09	3.24	2.58
Thyroid disease	5.67	4.48	5.97	3.03	2.56
High blood pressure (hypertension)	5.75	4.75	5.94	2.97	3.10
Parkinson's disease	6.06	4.59	5.88	4.84	3.16
Hemophilia	5.81	4.67	5.55	3.10	2.63
Developmental co-ordination disorders	5.33	4.63	5.69	5.53	3.17
Genetic fertility problems	5.75	4.57	5.72	3.77	3.05
Osteoporosis	5.87	4.81	6.26	2.71	2.58
Blindness	5.87	4.71	6.29	3.29	3.00
High cholesterol	5.47	4.93	6.14	2.53	2.73
Red-green colour blindness	5.74	4.71	5.93	3.59	2.93
Genetic predisposition to obesity	5.04	4.93	6.38	3.55	3.38
Baldness	5.61	4.74	5.99	3.51	2.94
Heart disease	5.93	4.90	6.28	2.55	2.34
Autoimmune disorders	5.90	4.62	5.97	2.97	2.55
Cystic fibrosis	6.10	4.72	6.03	3.28	2.48
Moles and birthmarks	3.00	4.72	6.17	2.45	2.28
Deafness	5.90	4.97	6.17	3.55	2.62
Genetic sleep disorders	5.83	4.79	5.48	4.45	2.97
Genetic predisposition to drug addiction	5.21	4.72	3.90	4.72	4.86
Facial asymmetries	2.90	4.49	6.17	2.41	2.38

Cognitive Therapy Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Learning disabilities associated with motor skills	5.50	4.80	5.68	5.53	3.62
Low IQ	3.81	3.97	3.03	5.66	4.13
Language learning disabilities	4.81	4.84	3.56	6.00	3.50
Schizophrenia	5.77	4.42	4.20	5.65	4.84
Mental retardation	5.94	4.87	4.39	6.19	4.45
Developmental delays	5.84	4.84	5.13	5.65	4.03
General memory deficits	5.06	5.06	3.52	6.10	3.94
ADD / ADHD	5.58	4.55	4.26	5.58	5.16
Alzheimer's	5.87	4.47	5.03	5.80	3.30
Autism	5.97	4.79	4.48	6.14	4.38
Homosexuality	5.60	4.73	4.32	5.89	4.20
Communication disorders	5.10	4.79	3.76	5.72	3.38
Down syndrome	5.64	4.73	4.34	5.86	4.24
Learning disabilities associated with memory	5.24	4.61	2.97	6.10	3.14
Agoraphobia	4.71	4.36	3.18	4.79	4.68
Age-related cognitive decline	4.83	5.07	3.59	6.30	3.18

Personality Therapy Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Bipolar disorder	5.69	4.78	3.97	5.59	5.63
Impulsivity issues	4.71	4.81	3.20	4.87	5.97
Depression	5.71	4.60	3.87	5.45	5.45
Jealousy	4.00	4.55	2.94	4.42	5.90
Narcissism / vanity	3.39	4.35	3.23	4.29	6.03
Extreme moodiness	4.67	4.80	3.36	4.50	6.23
Proneness to eating disorders	5.63	4.73	5.10	5.56	5.53
Obsessive thoughts	4.40	4.60	2.83	5.66	5.57
Compulsive behaviour	4.37	4.67	3.27	5.17	5.40
Antisocial behaviour	3.97	5.14	3.07	4.45	6.10
Suspiciousness and paranoia	4.52	4.68	3.46	4.94	5.78
Social phobias	4.37	4.69	3.41	4.87	5.82
Addictive personality	4.79	4.90	3.25	4.55	6.17
Pessimism	3.72	4.72	2.52	4.34	6.14
Phobias or extreme fears	4.97	4.62	3.00	5.66	5.07

Physical Enhancement Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Resistance to tanning / sunburn	3.76	4.67	5.72	2.75	2.67
Sense of hearing	5.38	5.47	5.94	3.85	2.74
Weight	4.47	5.26	6.38	3.81	4.13
Agility	4.06	5.84	6.38	3.91	3.38
Ageing	4.38	4.97	6.09	4.25	3.50
Ability to play a musical instrument	3.69	5.63	4.84	5.81	4.39
Physical energy	4.44	5.53	6.32	3.84	4.41
Muscles	4.13	5.55	6.52	2.84	3.29
Skin tone / colour	2.84	3.61	5.77	2.61	2.61
Eye colour	2.71	3.81	6.00	2.32	2.19
Hair colour	2.77	3.71	5.84	2.39	2.48
Athleticism	3.27	5.67	6.43	3.43	4.63
Gender	2.77	3.63	5.73	3.97	4.37
Hair thickness	3.14	4.45	6.31	2.03	2.03
Hand-eye coordination	3.69	5.66	6.24	5.17	2.45
Physical sense of balance	3.48	5.38	6.11	4.07	2.48
Physical reflexes	3.72	5.55	6.18	4.34	2.41
Facial symmetry	2.93	5.28	6.29	2.48	2.62
Height	3.48	4.86	6.52	2.52	2.80
Body type	3.28	5.28	6.55	2.48	2.69

Cognitive Enhancement Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Analytical thinking	3.00	5.97	2.65	6.06	5.24
IQ	3.08	5.97	3.17	6.19	4.86
Mental problem solving	3.53	5.50	3.00	6.19	5.17
Ability to think creatively	3.61	5.76	3.33	5.79	5.61
Handedness	3.34	4.25	5.19	4.13	2.50
Ability to learn languages	3.50	5.81	3.03	6.25	3.81
Mental reaction time	3.94	5.69	4.53	6.00	3.59
Ability to multitask	3.74	5.84	3.87	6.00	4.65
Ability to play or sing music by ear	3.47	5.60	3.60	5.82	4.43
Concentration	3.90	5.65	3.74	6.13	4.55
Musical ability	3.32	5.75	4.71	4.96	3.79
Intellectual perseverance	3.41	5.62	2.83	6.17	4.97
General memory	4.17	5.55	3.48	6.21	3.52
Photographic memory	3.38	5.86	3.48	6.28	3.21
Logical thinking	3.55	5.69	2.97	6.38	4.14
Mathematical ability	3.62	5.69	3.59	5.99	4.15
Artistic creativity	3.41	5.69	2.83	5.76	5.45

Personality Enhancement Items

	Goal		Type		
	Therapeutic	Enhancement	Physical	Cognitive	Personality
Confidence	3.66	5.77	2.69	4.43	6.28
Conscientiousness	3.22	5.19	2.81	5.25	5.73
Capacity for emotional commitment	3.81	5.19	2.89	5.32	6.11
Sensitivity	3.83	4.61	3.17	4.86	6.05
Optimism	3.71	5.31	2.60	5.23	6.44
Sense of humour	3.33	5.39	3.11	5.69	6.46
Self-discipline	3.72	5.22	3.22	5.42	6.11
Outgoingness	3.39	5.51	3.06	4.76	6.58
Friendliness	3.67	5.64	3.12	4.67	6.33
Agreeableness	3.55	5.34	2.95	4.88	6.27
Competitiveness	3.16	4.68	3.65	4.94	6.32
Passion	3.61	5.23	3.39	4.97	6.42
Open-mindedness	3.59	5.59	3.03	5.47	6.41
Ambition	3.28	4.97	4.07	5.40	4.50
Efficiency	3.30	5.47	4.07	5.40	4.50
Masculinity / femininity	2.97	4.20	5.33	3.90	4.83
Compassion	3.24	5.31	2.83	4.55	6.07
Sociability	3.28	5.34	2.90	4.31	6.41
Emotionality	3.44	5.21	3.43	4.85	5.89
Shyness	3.41	5.21	3.44	4.84	5.83

Appendix D – List of original essentialism items and adapted essentialism items

Item	Original wording used by Haslam, Rothschild, & Ernst (2000)	Adapted items used in Study One
Discreteness	"Some categories have sharper boundaries than others. For some, membership is clear-cut, definite, and of an 'either or' variety; people either belong to the category or they do not. For others, membership is more 'fuzzy'; people belong to the category in varying degrees."	"Being considered a human is clear-cut and definite; you cannot be a human in varying degrees."
Naturalness	"Some categories are more natural than others, whereas others are more artificial."	"The category of 'humans' is a natural category rooted in biology."
Immutability	"Membership in some categories is easy to change; it is easy for members to become non-members. Membership in other categories is relatively immutable; it is difficult for category members to become non-members."	"Being human is unchangeable. Humans cannot become non-humans."
Stability	"Some categories are more stable over time than others; they have always existed and their characteristics have not changed much throughout history. Other categories are less stable; their characteristics have changed substantially over time, and they may not have always existed."	"The human species a relatively stable category that has not changed much over time."
Necessity	"Some categories have necessary features or characteristics; without these characteristics someone cannot be a category member. Other categories have many similarities, but no features or characteristics are necessary for membership."	"There are certain features or characteristics that are necessary to be human."
Uniformity	"Some categories contain members who are very similar to one another; they have many things in common. Members of these categories are relatively uniform. Other categories contain members who differ greatly from one another, and don't share many characteristics."	"People are relatively similar to each other and share many characteristics."
Informativeness	"Some categories allow people to make judgments about their members; knowing that someone belongs to the category tells us a lot about that person. Other categories only allow a few Judgments about their members; knowledge of membership is not very informative."	"In the same way that knowing someone's occupation or political affiliation allows us to make inferences and judgments about that person, simply knowing that someone is human allows us to make inferences and judgments about them.
Inherence	"Some categories have an underlying reality; although their members have similarities and differences on the surface, underneath they are basically the same. Other categories also have similarities and	"All people share a common underlying essence; we may have similarities and on the surface, but underneath we are

	differences on the surface, but do not correspond to an underlying reality."	basically the same."
Exclusivity	"Some categories do not allow their members to belong to other categories; belonging to such a category excludes a person from these other categories. On the other hand, some categories do not limit which other categories their members can belong to; they do not exclude a person from these categories."	"Being human excludes you from membership in other comparable categories."