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Very Low Birthweight: Dysregulated gestation versus evolutionary adaptation

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Abstract

Much medical literature attributes persistently high rates of very low birthweight (VLBW) to “dysregulated” gestation. We offer the alternative view that natural selection conserved well-regulated, though nonconscious, decisional biology that protects the reproductive fitness of women by spontaneously aborting gestations that would otherwise yield frail infants, particularly small males. Modern obstetric practice, however, converts some fraction of these erstwhile spontaneous abortions into live births of very small infants. We further propose that the nonconscious decisional biology of gestation exhibits preferences also seen in consciously made decisions. We hypothesize that the incidence of VLBW among male infants should vary with the population's self-reported intentions to assume financial risk. We apply time-series modeling to monthly birth counts by sex and weight from the Swedish Medical Birth Registry between January 1993 and December 2010. We gauge risk aversion with monthly data from the Micro Index of the Swedish Consumer Tendency Survey (MISCT). Consistent with our argument that nonconscious decisional biology shares risk aversion with conscious decisions, we find that the incidence of VLBW among male infants in Sweden varies with the population's self-reported intentions to assume financial risk. We find increases above expected odds of a very low weight infant among males born 1 month after increases above expected levels of self-reported risk aversion in the Swedish population. We offer this finding as support for the argument that persistently high rates of VLBW arise, at least in part, from a combination of medical interventions and mechanisms conserved by natural selection to protect reproductive fitness.

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Keywords

Very low birthweight; perinatal health; risk aversion; selection in utero; decision-making; economy; Sweden

Males weighing less than 1,500 grams at birth suffer greater mortality and morbidity as neonates than larger male infants and females of equal or greater weight (Stevenson et al., 2000). Even in Sweden, a high-income country with accessible, high-quality medical care and progressive social policies, adult men born at very low weight (i.e., <1,500 grams) more likely exhibit health and behavioral deficits than men larger at birth or women born at equal or greater weight (Gaddlin et al., 2008).

The literature concerned with very low birthweight (VLBW) typically views the phenomenon as the product of dysregulated biology (Brou et al., 2012). We draw on economics, psychology, and evolutionary theory to offer the alternative view that natural selection conserved well-regulated decisional biology that protects the reproductive fitness of women by spontaneously aborting gestations that would otherwise yield infants unlikely to thrive in prevailing environments. Modern medical practice has, however, converted a fraction of these erstwhile spontaneous abortions into very low weight births. We further speculate that this selection *in utero*, which operates outside a woman's awareness, shares risk aversion with the decisions that she could report making in everyday life. As evidence of this shared risk aversion we show that the incidence of VLBW among male infants in Sweden varies with the population's self-reported intentions to assume financial risk. We conclude by arguing that obstetric medicine has helped introduce conscious decisional biases, which characterize many of our economic decisions, into reproductive choices previously made by less biased, though non-cognitive, decisional biology.

Selection *In Utero*

A long line of literature draws from evolutionary theory to shed light on commonalities and differences in the ways that human develop over the life course (Stearns, 1976). A subset of that work focuses on gestation because it provides not only the earliest environment for human maturation but also a site of selection against potentially less fit individuals (Møller, 1997). This literature includes the argument that pregnant women estimate, without awareness, the likelihood that a fetus, if born, will survive early life environments with sufficient vigor to reproduce as an adult (Catalano et al., 2012a; Catalano et al., 2012b). The argument assumes that a population of gestations begun at the same time in the same environment exhibits a normal distribution of hardiness. Small males disproportionately occupy the left (i.e., low value tail) of this distribution due to their relatively high likelihood of death and morbidity, despite receiving greater maternal investment (Clutton-Brock, 1991; Powe et al., 2010; Stevenson et al., 2000). This relatively great frailty explains why pregnancies of small males yield relatively few grandchildren for mothers (Lummaa, 2001).

If every fetus “presented” with the same hardiness, prospective mothers could still vary in their non-conscious willingness to assume the risk of a live birth because women vary in their ability to provide offspring with the resources needed to survive childhood. Women

vary, for example, in age, health, parity and socio-economic status, each of which may affect the time, energy, and other resources available to invest in prospective offspring. Each pregnant woman, therefore, may have her own critical value of fetal hardness below which a gestation spontaneously aborts. The distribution of these critical values in a population of pregnant women will exhibit an expected value, such as a mean or median, below which the incidence of spontaneous abortion occurs significantly more frequently than above. Increased environmental threats to infant survival or to maternal resources will shift this population-level criterion to the right as individual mothers protect their fitness and that of their children by non-consciously raising the level of fetal hardness needed to avoid spontaneous abortion. This right shift should, based on the assumptions listed above, lead to more spontaneous abortions of smaller males than of other fetuses.

Even in well-educated, high-income societies with accessible medical care, fewer than 50 percent of conceptions yield a live birth (Wilcox et al., 1999). Most of these losses occur before the 10th week of gestation and affect fetuses with chromosomal or other abnormalities that make survival, if born, unlikely in any environment. At least 16, and perhaps as many as 20, percent of post 10th week gestations, however, spontaneously abort (Buss et al., 2006). Fetuses lost after the 10th week exhibit relatively few detectable abnormalities but include a higher frequency of small for gestational age males than fetuses that survive to birth (Catalano et al., 2012a).

Best estimates suggest that post 10th week spontaneous abortions decline from a peak at the end of the first trimester (12th week) to a 16th week plateau that remains steady until approximately the 22nd week, when clinical interventions begin to yield very low weight infants, virtually all of whom gestate fewer than 36 weeks (Ammon Avalos et al., 2012; Goldhaber & Fireman, 1991). As predicted by our theory, males predominate among these births (Brettell et al., 2008). We assume that many of these births would have been, through nearly all of human history, spontaneous abortions that spared mothers from risky investment in frail offspring.

Women cannot report making the “decision” to spontaneously abort a gestation or describe the estimation of costs and benefits that informed such a choice. Psychologists have alluded to estimations and decisions that individuals cannot report making, but which can be brought into their consciousness using psychological techniques, as manifestations of “deep activation” (Dijksterhuis & Aarts, 2010; Sheeran et al., 2013; Wegner & Smart, 1997). Extending this notion, and consistent with modern rejection of the Cartesian separation of cognition from biology (Damasio, 1994; Jeannerod, 1997; Koestler, 1967; Ryle, 1949), we speculate that still deeper activation, out of awareness, not accessible to individual consciousness, and yet manifest in gestational outcomes, shares at least some of the preferences and biases that women and men exhibit in their conscious decisions (Sklar et al., 2012). Natural selection presumably conserved different levels of awareness in decision making for some purpose. We speculate that in the case of gestation, complete lack of awareness has protected maternal fitness by disallowing or mitigating biases now known to affect consciously made decisions (Haidt, 2012; Strough et al., 2011). These biases include the “sunk cost fallacy” that allows the decision to invest in option *o* at time *t* to increase the likelihood of investing in option *o* at time *t*+*n* (Ellingsen & Robles, 2012). If allowed to

affect the decisional biology of gestation as much as it affects cognitive choice, the sunk cost fallacy would lead mothers to continue gestations regardless of emergent frailties of fetuses. Natural selection would, therefore, conserve any emergent capability, such as deep activation, that protected the decisional biology of gestation against biases such as the sunk cost fallacy.

Our speculation suggests that variation over time in conscious risk aversion will coincide with non-conscious risk aversion revealed by a clinically important phenomenon -- the incidence of very low weight male births. More specifically, we hypothesize that self-reported reluctance of Swedish households to assume financial risks will predict reluctance, outside of awareness, to extend the gestation of small male fetuses and thereby increase the incidence of very low weight male births.

Although self-reported risk aversion does not respond to changes within the typical range of macroeconomic conditions (Barsky & Sims, 2009), we recognize that a macroeconomic shock to the orderly functioning of markets could induce cognitively realized risk aversion and, separately, “dysregulate” gestation. This circumstance would require modern medicine to rescue more very low weight infants when the population coincidentally reports less willingness to purchase durable goods. Indeed, the literature includes a report that the incidence of very low weight births in Sweden increases with rising unemployment (Catalano et al., 1999). We, therefore, included the unemployment rate in our tests. If unusually high unemployment predicts increased odds of very low birthweight but unexpectedly high risk aversion does not, we would infer that negative shocks to the macro-economy coincidentally dysregulate gestation and make the population risk averse. If unexpectedly high risk aversion predicts increased odds of very low birthweight but unusually high unemployment does not, we would infer that the previously reported association between unemployment and very low birthweight may arise from risk aversion induced, at least in part, by negative economic shocks. If both unexpectedly high risk aversion and unusually high unemployment predict increased odds of very low birthweight, we would infer that both risk aversion and “dysregulation” may independently affect gestation.

Methods

Data

The Micro Index of the Swedish Consumer Tendency Survey (MISCT) gauges risk aversion in monthly samples of 1,500 Swedish consumers aged 16-84 (“National Institute of Economic Research,” 2012). The MISCT combines responses to questions on present and anticipated (i.e., 12 months in the future) intentions to purchase durable goods. The Index equals the percent of respondents anticipating increased intentions less the percentage anticipating reduced intentions. The Index focuses on durable goods because their aggregate consumption varies more with self-reported risk aversion in the population than does the consumption of non-durables (Barsky & Sims, 2009).

The Swedish Medical Birth Registry provided us with monthly birth counts by sex and weight (“Swedish National Health Board,” 2012). We began our analyses with the first

month (i.e., January 1993) for which data were available for both the birth and consumer confidence measures. Our analyses end with December 2010, the most recent month for which we could obtain data at the time of our request.

We retrieved the monthly Swedish unemployment rate for our test period from Eurostat (Eurostat, 2012). The unemployment rate equals the number of unemployed persons (i.e., persons not working but wanting to work) divided by the unemployed plus the employed.

Analyses

We specified our tests to detect statistically significant (i.e., $p < .05$; 1-tailed test) associations between unexpected falls in the MISCT and the incidence of very low weight male births. We cannot know the distribution of survey completions over the weeks in our test months. Nor can we know how long medical practice may delay delivery of fetuses detected at risk of spontaneous abortion. We, therefore, infer support for our theory if very low weight births increase in the same month that surveyed risk aversion rises above expected levels or the month after. We test up to 8 months after unexpected increases in risk aversion to ensure that we detect associations with very low birthweight in all exposed gestations. Finding no increase in the odds of very low weight births among males born in the month of, or one month after, unexpected increases in risk aversion would refute our theory.

Our test proceeded through the following steps.

1. We estimated the expected monthly values of the MISCT so that we could identify months in which the Swedish population reported unexpectedly high risk aversion (i.e., unexpectedly low intention to purchase durable goods). Statistical tests of association typically assume that the expected value of any variable equals the mean of all its observations. Variables measured over time, however, often violate this assumption because they exhibit autocorrelation in the form of secular trends, cycles, or the tendency to remain elevated or depressed, or to oscillate, after high or low values. The expected value of an observation in such a series is not the mean of all observations but rather the value predicted by autocorrelation.

We used a method with properties that have led to acceptance in the biological and health sciences as an efficient approach to detecting and modeling autocorrelation (Bressler & Seth, 2011). The method, Autoregressive, Integrated, Moving Average (ARIMA) modeling, identifies which of a very large family of mathematical expressions best predicts measurements made over time (Box et al., 2008). The method assumes that the measurements passed through an unobserved filter, or model, that imposed autocorrelation upon them. The approach looks for patterns in the data that narrow the search to likely filters and then applies estimates of “fit” to identify the best fitting model. These models yield expected values that approximate what would have occurred if the circumstances that produced earlier values remained unchanged.

The residuals (i.e., difference between the expected and observed values) of the ARIMA model for the MISCT estimate the degree to which monthly risk aversion

among Swedes fell above or below expected levels. To create a variable that gauged months in which Swedes were unexpectedly risk averse, we rescored the positively scored residuals to 0.

2. We used the ARIMA routines (Box et al., 2008) described above to detect and model autocorrelation in the monthly unemployment rate. We assumed that, as in the case of cognitive risk aversion, only extreme values of economic indicators affect non-cognitive risk aversion (Barsky & Sims, 2009). We, therefore, used the methods of Chang et al to identify months in which positively signed residuals of the ARIMA model for the unemployment rate exceed their 99% (2-tailed test) confidence interval (Chang et al., 1988). We left the values for these extreme months in their continuous metric and rescored all other months to 0.
3. We calculated the monthly odds of a very low weight (i.e., <1,500 grams) male live birth (excluding multiple births). We transformed the odds to their natural logarithms (i.e., logits) to reduce the likelihood that variability in variation over time would affect our estimations and to allow us to express, as described below, any association we discovered in terms of the familiar “effect on odds” metric.
4. We applied ARIMA methods to the logits calculated in step 3 above to detect and model autocorrelation. We, in other words, arrived at the expected (i.e., from autocorrelation) odds of a very low weight male birth in any month.
5. We repeat the earlier test of association (Catalano et al., 1999) between unemployment and very low birthweight by adding the variable created in step 2 to the model developed in step 4. The earlier study reported that rising unemployment in the 3rd trimester of gestation increased the risk of very low birthweight so we specified our equation with unemployment variable in the same month as birth as well as in the prior 2 months.
6. We tested our hypothesis by estimating the equation formed by adding the residuals from the ARIMA model, derived in step 1, of the MISCT to the model developed in step 5 from which we removed any non-significant (i.e., $p < .05$, 1-tailed test) predictors. As noted above, we specified the equation such that unexpectedly high risk aversion predicted the likelihood of a very low weight male birth in the same month as well as up to 8 months later.
7. We pared the model developed in step 6 to those predictors significantly (i.e., $p < .05$, 1-tailed test) related to very low birthweight among males and rescored our continuous risk aversion variable to a binary indicator scored 1 when the original value had a negative sign and 0 otherwise. Estimating this model allowed us to express the association between risk aversion and very low birthweight among males in the familiar “effect on odds” metric.
8. We repeated steps 3 through 6 for females. Our theory predicts no associations will appear between risk aversion and very low birthweight.

Results

The monthly odds of a very low weight infant among male births in Sweden ranged from 0.0031 to 0.01 with a mean of 0.0057 over our test period. The monthly Swedish Micro Consumer Confidence Index ranged from -21.3 to 18.8 with a mean of 5.4.

Figure 1 shows the observed and the expected values, derived in step 1 above, of the MISCT. The best fitting ARIMA model of the MISCT was as follows.

$$\nabla Z_t = (1 - 0.1560B)a_t$$

Z_t is the MISCT at month t . ∇ is the difference operator indicating that secular trends (e.g., April 1995 to April 2000) in the MISCT required taking its first differences (i.e., value at month t subtracted from month $t-1$). a_t is the residual of the model at month t . 0.1560 is a moving average parameter indicating short term “memory” in which unusually high or low differences preceded high or low differences of declining absolute size by one month.

Figure 2 shows the observed and expected values, derived in step 2 above, of the monthly Swedish unemployment rate over the test period. The best fitting ARIMA model of the unemployment rate series was as follows.

$$\nabla \nabla_{12} Z_t = \frac{(1 - 0.4185B)(1 - 0.5031B^{12})}{(1 - 0.4900B^3)} a_t$$

Z is the unemployment rate at month t . ∇_{12} is the seasonal difference operator indicating that an annual cycle in the MISCT required taking differences at month 12 (i.e., value at month t subtracted from month $t-12$). Both -0.4185 and -0.5031 are moving average parameters. -0.4900 is an autoregressive parameter indicating that high or low values in the unemployment rate exhibited “echoes” 3 months later.

Figure 3 shows the observed and expected values, derived in step 4 above, of the natural logarithms of the odds (i.e., logits) of a very low weight infant among males born over the test period. The best fitting ARIMA model of this series was as follows.

$$Y_t = -5.1964 + \frac{1}{(1 - 0.1857B)(1 + 0.1828B^5)} a_t$$

Y_t is the natural logarithm of the odds of a very low weight infant among males born at month t . Both -0.1857 and 0.1828 are autoregressive parameters indicating that high or low values in the likelihood of a very low weight male birth exhibited “echoes” 1 and 5 months later.

Table 1 shows the results of step 5 in which we estimated the association between unusually high unemployment and the odds of very low birthweight among males. Consistent with the

association reported in 1999, the logit of a very low weight infant among male births increased significantly above the expected value 2 months after unusually high unemployment.

Table 2 shows the results of step 6 in which we estimated our primary test equation. Consistent with our hypothesis, the logit of a very low weight infant among male births increased significantly above expected values 1 month after Swedes reported unexpectedly low intentions to assume financial risk. The coefficient for unemployment, however, falls below significance in the test equation.

Table 3 shows the results of step 7 in which we reduced the model developed in step 6 to those predictors significantly (i.e., $p < .05$, 1-tailed test) related to very low birthweight among males and rescored our continuous risk aversion variable to a binary indicator scored 1 when the original value had a negative sign and 0 otherwise. This estimation allows us to express our finding in the familiar “effect on odds” metric. To do so, we subtracted 1 from the antilog of 0.0542 and multiplied the difference by 100. The result showed that the odds of a very low weight infant among male births rose approximately 5.5% above expected levels 1 month after Swedes reported unexpectedly great aversion to financial risk.

We repeated our test for very low weight among females. Consistent with theory, we found no significant associations between MISCT and the risk of very low weight births among females.

Discussion

We find unexpected increases in the odds of a very low weight infant among males born 1 month after unexpected increases in self-reported risk aversion in the Swedish population. We offer this finding as support for the argument that the non-conscious decisional biology responsible for selection *in utero* shares at least some preferences with conscious decision making in everyday life.

Our argument implies that a fraction of very low weight births arise not from “dysregulated” or malfunctioning biology that medicine can set right, but rather from medicine's response to a well-regulated but non-conscious mechanism conserved by natural selection to protect reproductive fitness. Estimating the costs and benefits of this response involves ethical and other considerations beyond the scope of this paper. We note, however, that medicine's response appears consistent with the sunk-cost fallacy that characterizes many conscious decisions.

We also find that the previously reported (Catalano et al., 2010) bivariate association between unemployment in Sweden and the likelihood of very low weight births does not persist when models include unexpected risk aversion. The risk aversion variable, however, remains significantly associated with very low birthweight when models include unemployment. This circumstance leads intuitively to the suspicion that the previously reported association may arise from the effect of unusually high unemployment on risk aversion. The fact that controversy remains over the determinants of risk aversion in the population (Barsky & Sims, 2009) should, however, temper this inference.

Our findings converge with the analogy, offered earlier in the literature (Forbes, 2009; Markowitz, 1952), between selection *in utero* and “portfolio theory” (Markowitz, 1952). A woman has a portfolio of living and/or potential children among whom she must invest her limited resources including time and energy. Throughout pregnancy, her non-conscious decisional biology makes choices on whether to continue investing in the fetus given the other opportunities in her portfolio. Those choices have a profound effect on her fitness and the fitness of her offspring. Natural selection would, therefore, have conserved mutations that reduced poor choices (Dawkins & Carlisle, 1976). Decisions made consciously appear subject to many biases, including the sunk cost fallacy, that foster poor choices (Haidt, 2012; Strough et al., 2011).

Our test benefits from a complete count of births observed over many months in a country known for high-quality vital statistics. This long series of monthly data allows us to use the most rigorous methods available to control for autocorrelation in both our independent and dependent variables. Our finding cannot, therefore, arise spuriously from shared trends, seasonality, or regression to expected levels after high or low values.

As with all observational tests, ours poses essentially a “refutation challenge.” Accepting the null hypothesis would have made our arguments difficult to defend but rejecting the null does not confirm them. Our results, rather, justify, and perhaps add impetus to, additional refutation challenges. Any such tests should focus on infant characteristics known to reduce the fitness of offspring. Gestations of male twins, for example, yield relatively few grandchildren for women suggesting that the odds of a twin among male births should fall after when the population becomes increasingly risk averse (Catalano et al., 2009; Helle et al., 2004). Outcomes such as the male twin ratio have less clinical significance than does very low birthweight, but they may provide equivalently strong tests of the theory.

Additional tests would optimally vary in their methods. Strategies for arriving at counterfactuals for time-series fall into two general categories – those that derive expected values from comparison populations and those that derive them from “history” (Bressler & Seth, 2011; Campbell & Ross, 1968). We have depended primarily on the latter approach implemented by ARIMA modeling. Additional research might use the former approach implemented through, for example, fixed effect panel designs to determine how sensitive any associations reported in the literature might be to test artifacts (Drukker, 2003).

Our findings imply that mechanisms conserved by natural selection to reduce the influence of the sunk cost fallacy and similar biases on gestation include a form of deep activation that involves evaluations not accessible to individual consciousness but, when combined with modern obstetric medicine, become discernible in the aggregation of gestational outcomes. These outcomes include an increase in very low weight births among males and its sequelae.

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References

- Ammon Avalos L, Galindo C, Li DK. A systematic review to calculate background miscarriage rates using life table analysis. *Birth defects research Part A, Clinical and molecular teratology*. 2012; 94:417–423.
- Barsky, RB.; Sims, ER. Information, animal spirits, and the meaning of innovations in consumer confidence. National Bureau of Economic Research; 2009.
- Box, G.; Jenkins, G.; Reinsel, G. *Time Series Analysis: Forecasting and Control*. Hoboken, NJ: Wiley; 2008.
- Bressler SL, Seth AK. Wiener–Granger causality: a well established methodology. *Neuroimage*. 2011; 58:323–329. [PubMed: 20202481]
- Brettell R, Yeh PS, Impey LW. Examination of the association between male gender and preterm delivery. *Eur J Obstet Gynecol Reprod Biol*. 2008; 141:123–126. [PubMed: 18783867]
- Brou L, Almli LM, Pearce BD, Bhat G, Drobek CO, Fortunato S, et al. Dysregulated biomarkers induce distinct pathways in preterm birth. *BJOG*. 2012; 119:458–473. [PubMed: 22324919]
- Buss L, Tolstrup J, Munk C, Bergholt T, Ottesen B, Gronbaek M, et al. Spontaneous abortion: a prospective cohort study of younger women from the general population in Denmark. Validation, occurrence and risk determinants. *Acta Obstet Gynecol Scand*. 2006; 85:467–475. [PubMed: 16612710]
- Campbell DT, Ross HL. The Connecticut crackdown on speeding: Time-series data in quasi-experimental analysis. *Law & Society Review*. 1968; 3:33–53.
- Catalano R, Goodman J, Margerison-Zilko CE, Saxton KB, Anderson E, Epstein M. Selection against small males in utero: a test of the Wells hypothesis. *Human Reproduction*. 2012a; 27:1202–1208. [PubMed: 22298840]
- Catalano R, Hansen HT, Hartig T. The ecological effect of unemployment on the incidence of very low birthweight in Norway and Sweden. *J Health Soc Behav*. 1999; 40:422–428. [PubMed: 10643164]
- Catalano R, Margerison-Zilko C, Goldman-Mellor S, Pearl M, Anderson E, Saxton K, et al. Natural selection in utero induced by mass layoffs: the hCG evidence. *Evolutionary Applications*. 2012b:no–no.
- Catalano R, Saxton K, Bruckner T, Goldman S, Anderson E. A sex-specific test of selection in utero. *Journal of Theoretical Biology*. 2009; 257:475–479. [PubMed: 19146859]
- Catalano R, Zilko CE, Saxton KB, Bruckner T. Selection in utero: a biological response to mass layoffs. *Am J Hum Biol*. 2010; 22:396–400. [PubMed: 19918916]
- Chang I, Tiao G, Chen C. Estimation of time series parameters in the presence of outliers. *Technometrics*. 1988; 30:193–204.
- Clutton-Brock, T. *The evolution of parental care*. Princeton, NJ: Princeton University Press; 1991.
- Damasio, AR. *Descartes' error: emotion, reason, and the human brain*. New York: Putnam; 1994.
- Dawkins R, Carlisle TR. Parental investment, mate desertion and a fallacy. *Nature*. 1976; 262:131–132.
- Dijksterhuis A, Aarts H. Goals, attention, and (un)consciousness. *Annual review of psychology*. 2010; 61:467–490.
- Drukker DM. Testing for serial correlation in linear panel-data models. *Stata Journal*. 2003; 3:168–177.
- Ellingsen T, Robles J. The evolution of parental investment: re-examining the anisogamy argument. *J Theor Biol*. 2012; 299:113–119. [PubMed: 21996471]
- Eurostat. *Unemployment Statistics*. 2012
- Forbes S. Portfolio theory and how parent birds manage investment risk. *Oikos*. 2009; 118:1561–1569.
- Gaddlin PO, Finnstrom O, Samuelsson S, Wadsby M, Wang C, Leijon I. Academic achievement, behavioural outcomes and MRI findings at 15 years of age in very low birthweight children. *Acta Paediatr*. 2008; 97:1426–1432. [PubMed: 18624991]
- Goldhaber MK, Fireman BH. The fetal life table revisited: spontaneous abortion rates in three Kaiser Permanente cohorts. *Epidemiology*. 1991; 2:33–39. [PubMed: 2021664]

- Haidt, J. *The Righteous Mind: Why Good People Are Divided by Politics and Religion*. Pantheon; 2012.
- Helle S, Lummaa V, Jokela J. Accelerated immunosenescence in preindustrial twin mothers. *Proc Natl Acad Sci U S A*. 2004; 101:12391–12396. [PubMed: 15295101]
- Jeannerod, M. *The cognitive neuroscience of action*. Oxford, OX; Cambridge, MA: Blackwell; 1997.
- Koestler, A. *The ghost in the machine*. London: Hutchinson; 1967.
- Lummaa V. Reproductive investment in pre-industrial humans: the consequences of offspring number, gender and survival. *Proc Biol Sci*. 2001; 268:1977–1983. [PubMed: 11571043]
- Markowitz H. Portfolio Selection*. *The Journal of Finance*. 1952; 7:77–91.
- Møller AP. Developmental Selection Against Developmentally Unstable Offspring and Sexual Selection. *Journal of Theoretical Biology*. 1997; 185:415–422.
- National Institute of Economic Research. (2012). Stockholm, Sweden.
- Powe CE, Knott CD, Conklin-Brittain N. Infant sex predicts breast milk energy content. *Am J Hum Biol*. 2010; 22:50–54. [PubMed: 19533619]
- Ryle, G. *The concept of mind*. London, New York: Hutchinson's University Library; 1949.
- Sheeran P, Gollwitzer PM, Bargh JA. Nonconscious processes and health. *Health Psychol*. 2013; 32:460–473. [PubMed: 22888816]
- Sklar AY, Levy N, Goldstein A, Mandel R, Maril A, Hassin RR. Reading and doing arithmetic nonconsciously. *Proc Natl Acad Sci U S A*. 2012; 109:19614–19619. [PubMed: 23150541]
- Stearns SC. Life-history tactics: a review of the ideas. *Quarterly review of biology*. 1976:3–47. [PubMed: 778893]
- Stevenson DK, Verter J, Fanaroff AA, Oh W, Ehrenkranz RA, Shankaran S, et al. Sex differences in outcomes of very low birthweight infants: the newborn male disadvantage. *Arch Dis Child Fetal Neonatal Ed*. 2000; 83:F182–185. [PubMed: 11040165]
- Strough J, Karns TE, Schlosnagle L. Decision making heuristics and biases across the life span. *Annals of the New York Academy of Sciences*. 2011; 1235:57–74. [PubMed: 22023568]
- Swedish National Health Board. 2012.
- Wegner DM, Smart L. Deep Cognitive Activation: A New Approach to the Unconscious. *Journal of Consulting and Clinical Psychology*. 1997; 65:984–995. [PubMed: 9420359]
- Wilcox AJ, Baird DD, Weinberg CR. Time of implantation of the conceptus and loss of pregnancy. *N Engl J Med*. 1999; 340:1796–1799. [PubMed: 10362823]

Research Highlights

Non-conscious choices that regulate gestation share preferences with conscious decision making.

Consumer confidence surveys predict the odds of male very low weight birth (VLWB) in Sweden.

Temporal variation in VLBW arises in part from clinical strategies to reduce selection in utero.

Figure 1.

Expected and observed monthly Micro Index of the Swedish Consumer Tendency Survey (January 1993 through December 2010; 1 month of expected values lost to modeling).

Figure 2.

Expected and observed Swedish monthly unemployment rate (January 1993 through December 2010; 16 months of expected values lost to modeling).

Figure 3.

Expected and observed monthly logits of a very low weight male birth from (January 1993 through December 2010; 6 months of expected values lost to modeling).

Table 1

Coefficients for model predicting logits of a very low weight male birth in Sweden from unusually high unemployment (n= 216 months; January 1993 through December 2010).

Parameter	Coefficient	Standard Error
Constant	-5.2030*	0.0156
Unemployment		
In month of birth	0.1021	0.0940
1 month before birth	0.0975	0.0953
2 months before birth	0.1771*	0.0941
Autoregression at 1 month	0.1623*	0.0686
Autoregression at 5 months	-0.1786*	0.0691

*
p<.05;

1-tailed test

Table 2

Coefficients for model predicting logits of a very low weight male birth in Sweden from unexpected risk aversion and unemployment (n=216 months; January 1993 through December 2010).

Parameter	Coefficient	Standard Error
Constant	-5.2185*	0.0318
Unemployment 2 months before birth	0.1554	0.1001
Unexpected risk aversion at:		
Month of birth	-0.0078	0.0109
1 month earlier	-0.0269*	0.0110
2 months earlier	0.0006	0.0110
3 months earlier	0.0018	0.0117
4 months earlier	-0.0036	0.0108
5 months earlier	0.0046	0.0111
6 months earlier	0.0098	0.0112
7 months earlier	-0.0069	0.0110
8 months earlier	0.0045	0.0109
Autoregression at 1 month	0.18655*	0.0696
Autoregression at 5 months	-0.1866*	0.0708

*
p< .01;

1-tailed test

Table 3

Coefficients for model predicting logits of a very low weight male birth in Sweden from binary variable scored 1 for months with unexpectedly high risk aversion and 0 otherwise (n= 216 months; January 1993 through December 2010).

Parameter	Coefficient	Standard Error
Constant	-5.2195*	0.0201
Binary unexpected risk aversion		
1 month before birth	0.0542*	0.0283
Autoregression at 1 month	0.1685*	0.0685
Autoregression at 5 months	-0.1183*	0.0687

*
p< .05;

1-tailed test