

Machine Learning and Computational Social Science

Intersections and Collisions

David Jensen

Department of Computer Science
University of Massachusetts Amherst

17 December 2011



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Introduced new representations and algorithms

0 1 2 3 4 5 6 7 8 9

CCXXVI \longrightarrow 226

$$226 = (2 \times 100) + (2 \times 10) + 6$$

$$\begin{array}{r} 226 \\ + 471 \\ \hline 697 \end{array}$$

$$\begin{array}{r} 382 \\ \times 16 \\ \hline 6112 \end{array}$$

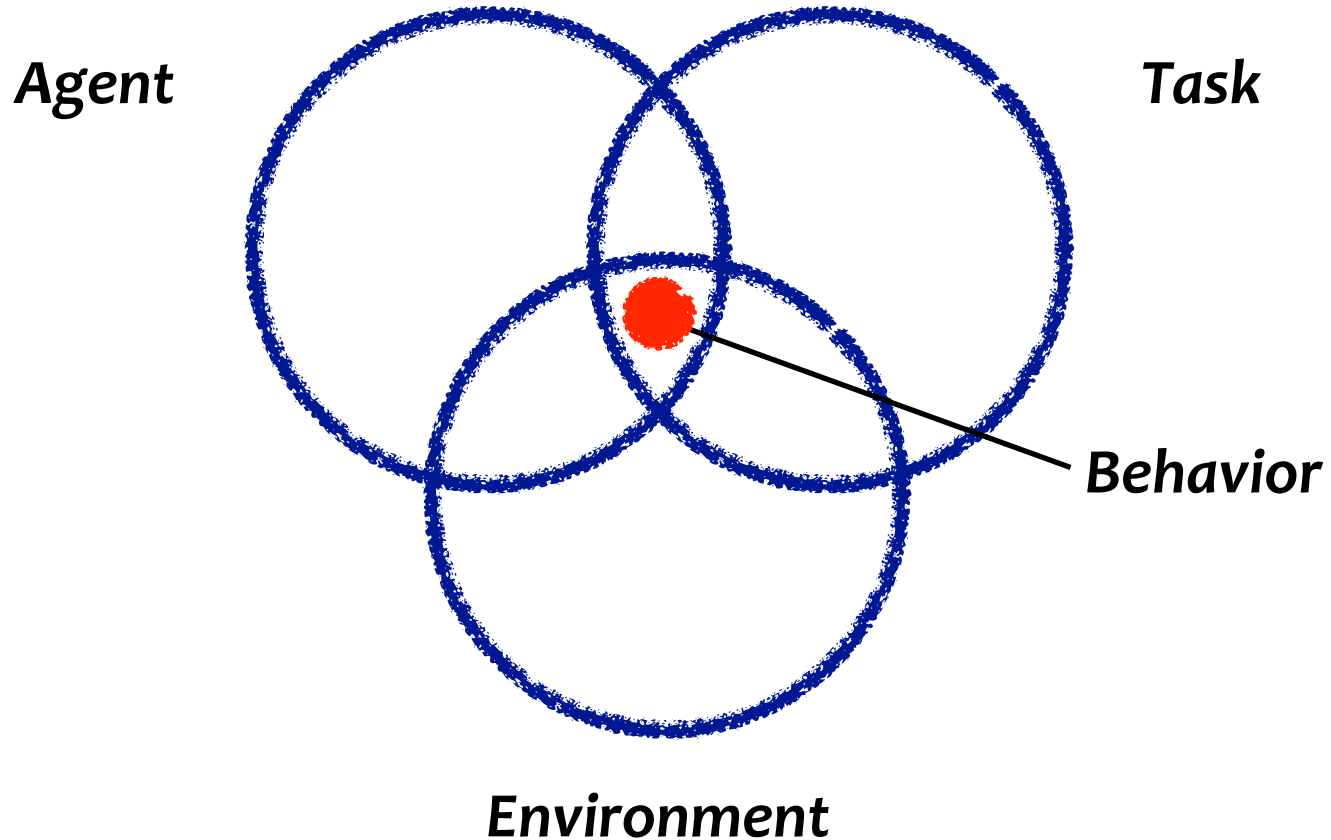
$$\frac{3}{8} + \frac{1}{4} = \frac{5}{8}$$

Displaced existing methods



Computational Social Science

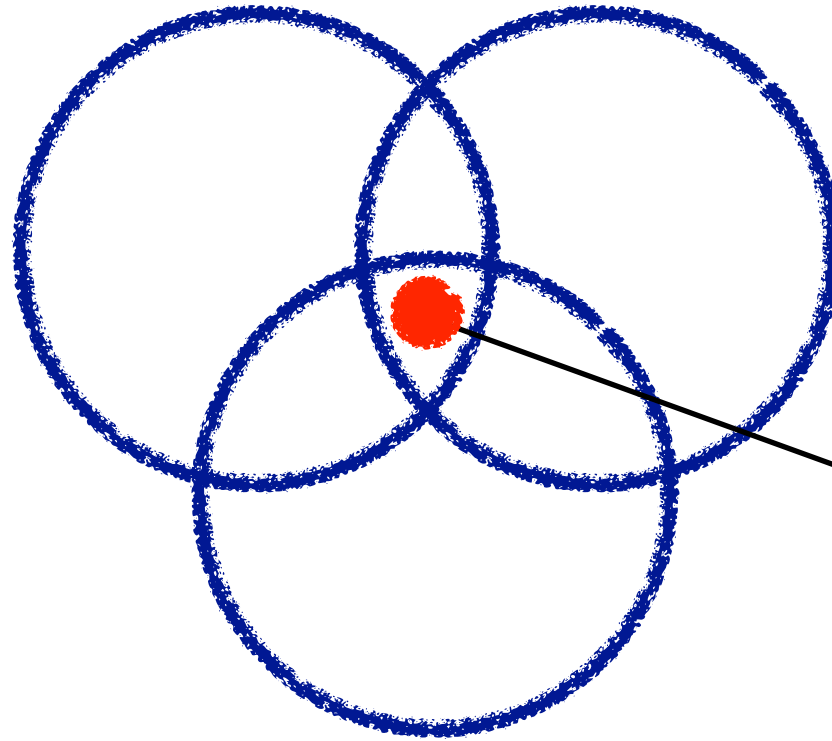
Decomposing research problems



Example

Agent
Person

Task
Job-hunting

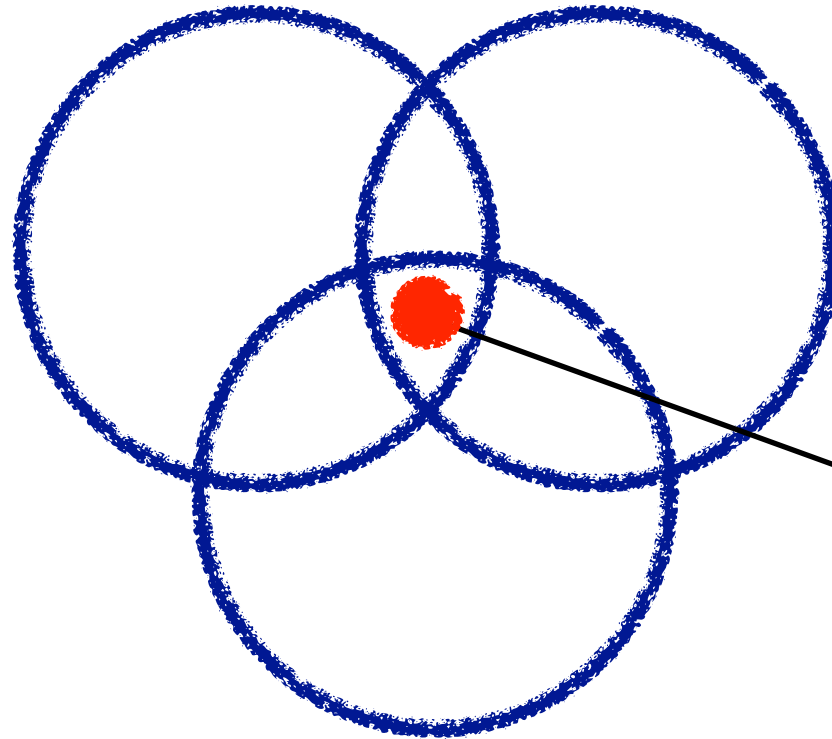


Behavior
Exploiting the
strength of
weak ties
(Granovetter 1973)

Environment
Social network of friends and acquaintances

Traditional social science

Agent
Scientists



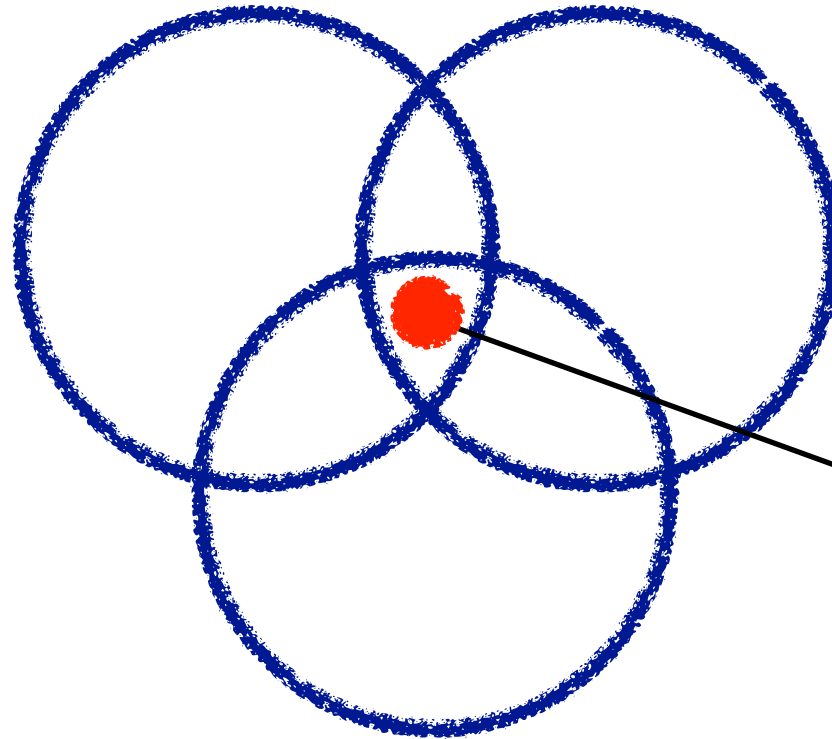
Task
Understand the
behavior of
social systems

Behavior
Current research
practices in
social science

Environment
Available data and analytic methods

Computational social science

Agent
Scientists
+ Computation

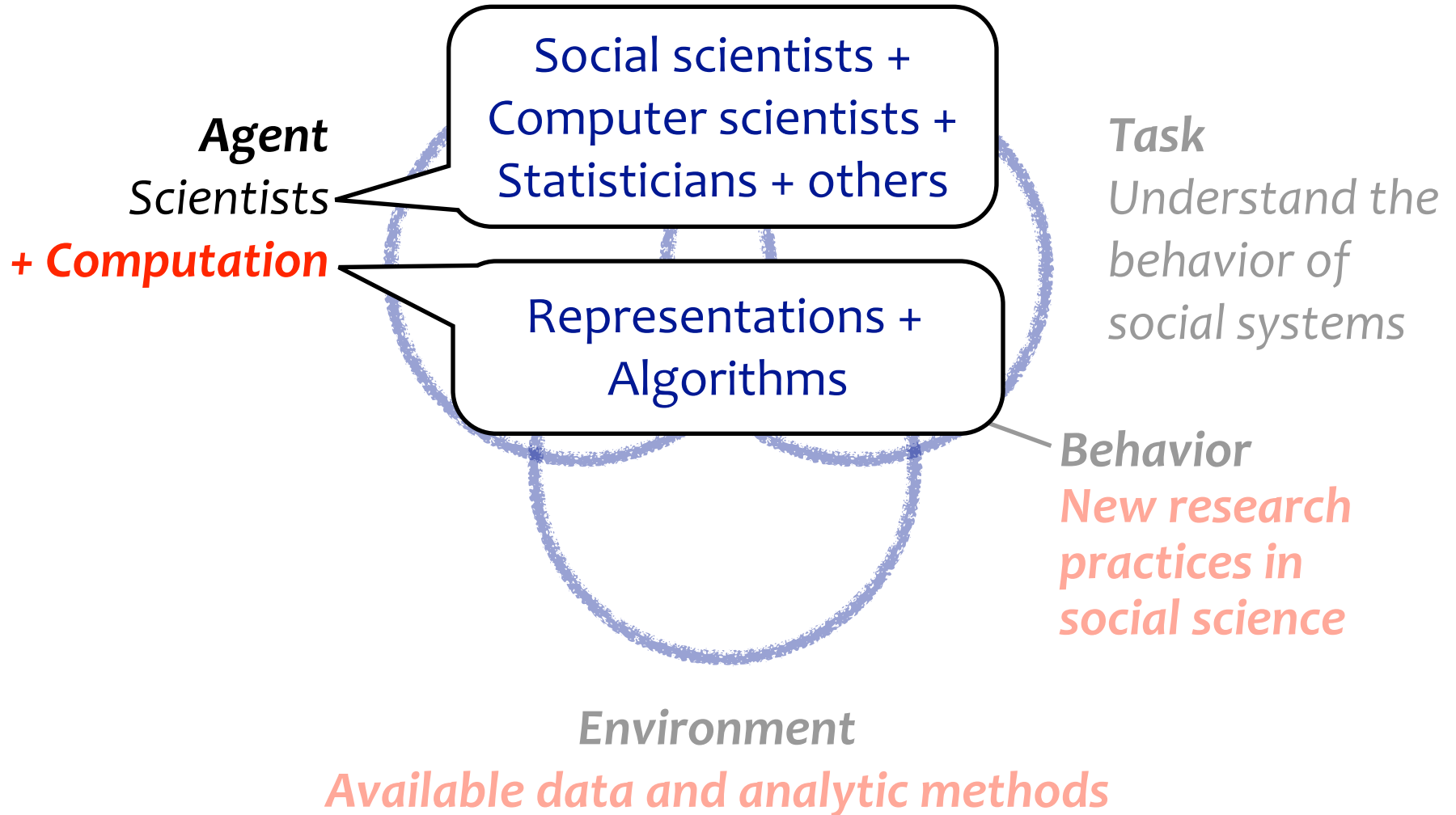


Task
Understand the
behavior of
social systems

Behavior
**New research
practices in
social science**

Environment
Available data and analytic methods

Computational social science



Key question

**Given the *environment* and *task*,
what *representations* and *algorithms*
are most appropriate?**

Also:

What new *tasks* can we accomplish,
given agents and environments?

What new *environments* can be studied,
given existing tasks and agents

Key points

- The *environments* and *tasks* of social science make new requirements on the representations and algorithms from computer science and statistics.
- Unless we adapt computational representations and algorithms to that new context, they are unlikely to be widely adopted and used.
- If we adapt, radical improvements are possible in our understanding of social systems.

Example

Adolescent Sexual Debut and Later Delinquency

Stacy Armour · Dana L. Haynie

Received: 31 May 2006 / Accepted: 7 August 2006 / Published online: 13 September 2006
© Springer Science+Business Media, Inc. 2006

Abstract Does sexual debut (i.e., experiencing sexual intercourse for the first time) increase the risks of participating in later delinquent behavior? Does this risk increase if adolescents experience early sexual debut relative to the timing experienced by one's peers? Although many factors have been linked to sexual debut, little research has examined whether sexual initiation is linked to later behavioral outcomes. Using data on adolescents participating in three waves of the National Longitudinal Study of Adolescent Health ($N = 7,297$), we examine the interconnections between sexual debut and later delinquency. In addition, we pay particular attention to the role of timing of sexual debut. We find that experiencing sexual debut is associated with delinquency one year later. In addition, those adolescents who experience early sexual debut relative to their peers are at higher risk of experiencing delinquency compared to those who debut on-time; adolescents who experience late sexual debut are the least likely to participate in delinquency. Moreover, the protective effect of late sexual debut appears to persist for several years. Findings are interpreted by drawing on developmental theory and life course research.

Introduction

Interest in the timing, prediction, and consequences of sexual initiation continues to garner much research attention. In part, this interest has resulted from the steadily declining age at which adolescents begin having sex and the finding that in the U.S. most adolescents report having had

sex by the time they graduate from high school (Singh and Darroch, 2000). Indeed, recent political discussion has focused on teen sexual activity and the promotion of abstinence education because of the concern that sex outside of marriage is likely to have deleterious consequences for youth. However, despite the common assumption that sexual initiation in general, and early sexual debut in particular, is likely to result in problematic behaviors, no research to our knowledge has systematically evaluated this claim. Although many factors have been linked to early sexual debut, little research has focused on whether early sexual initiation is linked to problem behaviors such as involvement in delinquency later in the life course. Therefore, the purpose of this research is to examine the association between sexual debut and later adolescent delinquency, with a particular focus on early sexual debut.¹

Although engaging in delinquency is not uncommon during adolescence (Moffitt, 1993) there is evidence that for some adolescents, delinquency can have lasting effects reducing social and human capital that can then result in diminished economic and social opportunities in young adulthood (Hagan, 1998; Hagan et al., 1996). This may be particularly the case if adolescents engage in delinquency at a young age. For instance, if early sexual debut initiates or results in elevated delinquency. Therefore, examining the associations between sexual debut and later delinquency is warranted.

Developmental theory is instrumental in explaining how early sexual initiation can open the doorway to other behaviors. Of primary interest here, developmental theory and life course research suggest that timing of sexual debut is

¹ By sexual debut we refer to transitioning from virgin to non-virgin status based on self-reported information on the experience of sexual intercourse.

(Armour & Haynie 2007)

Rethinking Timing of First Sex and Delinquency

K. Paige Harden · Jane Mendle · Jennifer E. Hill ·
Eric Turkheimer · Robert E. Emery

Received: 24 July 2007 / Accepted: 11 September 2007
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Abstract The relation between timing of first sex and later delinquency was examined using a genetically informed sample of 534 same-sex twin pairs from the National Longitudinal Study of Adolescent Health, who were assessed at three time points over a 7-year interval. Genetic and environmental differences between families were found to account for the association between earlier age at first sex and increases in delinquency. After controlling for these genetic and environmental confounds using a quasi-experimental design, earlier age at first sex predicted lower levels of delinquency in early adulthood. The current study is contrasted with previous research with non-genetically informative samples, including Armour and Haynie (2007, *Journal of Youth and Adolescence*, 36, 141–152). Results suggest a more nuanced perspective on the meaning and consequences of adolescent sexuality than is commonly put forth in the literature.

Keywords Adolescent sexual behavior · First sex · Sexual debut · Delinquency · Behavior genetics

Introduction

Armour and Haynie recently published a report on "Adolescent sexual debut and later delinquency" in the February 2007 issue of *Journal of Youth and Adolescence*. The authors' stated intent was to examine whether earlier "sexual debut," relative to peers, increases the

risk for delinquent behavior. The authors successfully utilized a large and complex data set—the National Longitudinal Study of Adolescent Health—to demonstrate that adolescents who have experienced first sex in the past year exhibited higher levels of delinquency compared to adolescents who remained virgins. In addition, adolescents who experienced first sex earlier than their same-school peers exhibited an increase in delinquency later in adolescence and early adulthood, controlling for previous delinquency. Overall, this was an interesting analysis of the relations among variables of considerable developmental interest. We have no qualms with either the content or the execution of the analysis itself. Nevertheless, Armour and Haynie's (2007) interpretation of their results typifies a problem commonly encountered in the literature on adolescent development—drawing unwarranted causal conclusions from non-experimental data.

Armour and Haynie are no doubt well aware of the logical pitfalls of concluding that X causes Y from non-experimental data. Yet, like many researchers, they interpret an epidemiological association between the timing of first sex and delinquency—with little or no qualification—as evidence that early first sex causes later delinquency. For example, they conclude that "the timing...of events such as sexual activity has profound consequences" (p. 149) and that "experiencing early or late sexual debut continues to have consequences for delinquent behavior occurring in young adulthood" (p. 150). An alternative explanation for their findings, of course, is that a third variable, either environmental or genetic, is associated with both timing of first sex and later delinquent behavior. That is, the association between early sex and later delinquency reported by Armour and Haynie (2007) could be an artifact of uncontrolled confounds.

(Harden et al. 2007)

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Introduction

Interest in the timing, prediction, and consequences of sexual initiation continues to garner much research attention. In part, this interest has resulted from the steadily declining age at which adolescents begin having sex and the finding that in the U.S. most adolescents report having had

sex by the time they graduate from high school (Singh and Darroch, 2000). Indeed, recent political discussion has focused on teen sexual activity and the promotion of abstinence education because of the concern that sex outside of marriage is likely to have deleterious consequences for youth. However, despite the common assumption that sexual initiation in general, and sexual debut in particular, is likely to result in poorer outcomes, no research to our knowledge has examined this claim. Although many studies have examined the timing of sexual debut, little research has focused on whether sexual initiation is linked to problem behavior, such as involvement in delinquency later in the life course. The purpose of this research is to examine the association between sexual debut and later adolescent delinquency, with a particular focus on early sexual debut.

Although engagement in delinquency is not uncommon during adolescence (Moffitt, 1993) there is evidence that for some adolescents, delinquency can have lasting effects reducing social and human capital that can then result in diminished economic and social opportunities in young adulthood (Hagan, 1998; Hagan et al., 1996). This may be particularly the case if adolescents engage in delinquency at a young age. For instance, if early sexual debut initiates or results in elevated delinquency. Therefore, examining the associations between sexual debut and later delinquency is warranted.

Developmental theory is instrumental in explaining how early sexual initiation can open the doorway to other behaviors. Of primary interest here, developmental theory and life course research suggest that timing of sexual debut is

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Armour and Haynie are no doubt well aware of the logical pitfalls of concluding that X causes Y from non-experimental data. Yet, like many researchers, they interpret an epidemiological association between the timing of first sex and delinquency—with little or no qualification—as evidence that early first sex causes later delinquency. For example, they conclude that "the timing of events such as sexual activity has profound consequences" (p. 149) and that "experiencing early or late sexual debut continues to have consequences for delinquent behavior occurring in young adulthood" (p. 150). An alternative explanation for their findings, of course, is that a third variable, either environmental or genetic, is associated with both timing of first sex and later delinquent behavior. That is, the association between early sex and later delinquency reported by Armour and Haynie (2007) could be an artifact of uncontrolled confounds.

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(Harden et al. 2007)

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sex by the time they graduate from high school (Singh and Darroch, 2000). Indeed, recent political discussion has focused on teen sexual activity and the promotion of abstinence education because of the concern that sex outside of marriage is likely to have deleterious consequences for youth. However, despite the common assumption that sexual initiation in general, and early sexual debut in particular, is likely to result in poor outcomes, no research to our knowledge has supported this claim. Although many studies have examined the association between sexual debut and later delinquency, with a particular focus on early sexual debut (e.g., Moffitt, 1993), little research has focused on the role of timing of sexual initiation to problem behavior. The current study's contribution to the literature is to examine the association between sexual debut and later delinquency, with a particular focus on early sexual debut.

Although engaging in delinquency is not uncommon during adolescence (Moffitt, 1993) there is evidence that for some adolescents, delinquency can have lasting effects reducing social and human capital that can then result in diminished economic and social opportunities in young adulthood (Hagan, 1998; Hagan et al., 1996). This may be particularly the case if adolescents engage in delinquency at a young age. For instance, if early sexual debut initiates or results in elevated delinquency. Therefore, examining the associations between sexual debut and later delinquency is warranted.

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Early Sex → Delinquency

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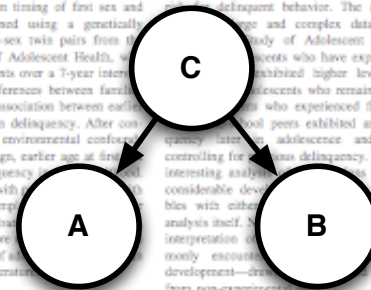
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Genetics and Family Environment



Early Sex → Delinquency

delinquent behavior. The authors successfully demonstrate a complex data set—the National Longitudinal Study of Adolescent Health—to demonstrate that adolescents who have experienced first sex in early adolescence exhibited higher levels of delinquency later in life. The authors' findings suggest that genetic and environmental differences between families of adolescents who experienced first sex earlier than their peers exhibited an increase in delinquency later in adolescence and early adulthood, controlling for these genetic and environmental confounds using a quasi-experimental design, earlier age at first sex predicted lower levels of delinquency later in life. The current study is contrasted with previous research on non-genetically informative samples. The current study's interpretation of the results is discussed in relation to the existing and consequences of adolescent delinquency, which is commonly put forth in the literature.

Armour and Haynie are no doubt well aware of the logical pitfalls of drawing causal conclusions from non-experimental data. If, from non-experimental data, they were to draw causal conclusions, they interpret an epidemiological association between the timing of first sex and delinquency—with little or no qualification—as evidence that early first sex causes later delinquency. For example, they conclude that "the timing of events such as sexual activity has profound consequences" (p. 149) and that "experiencing early or late sexual debut continues to have consequences for delinquent behavior occurring in young adulthood" (p. 150). An alternative explanation for their findings, of course, is that a third variable, either environmental or genetic, is associated with both timing of first sex and later delinquent behavior. That is, the association between early sex and later delinquency reported by Armour and Haynie (2007) could be an artifact of uncontrolled confounds.

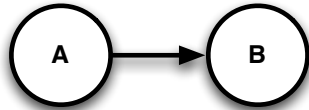
(Harden et al. 2007)

What is causality?

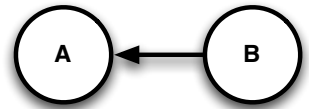
“The paradigmatic assertion in causal relationships is that manipulation of a cause will result in the manipulation of an effect... Causation implies that by varying one factor, I can make another vary.”

– *Cook & Campbell (1979)*

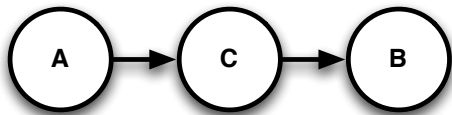
Causal structures producing association



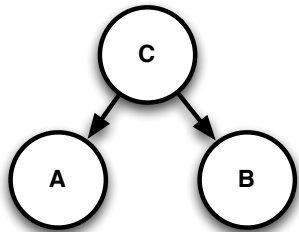
Direct causation — A causes B in the expected direction.



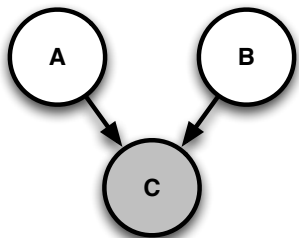
Reverse causation — A causes B in the reverse direction.



Causal chain — A indirectly causes B through C .

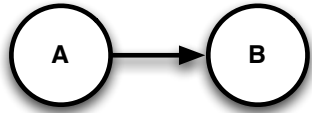


Common cause — The variable C causes both A and B , thus inducing a dependence between A and B .



Conditioning on a common effect — A and B share a common effect C , and conditioning on this variable can induce a dependence between A and B .

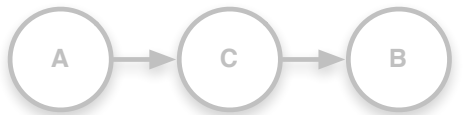
Causal structures producing association



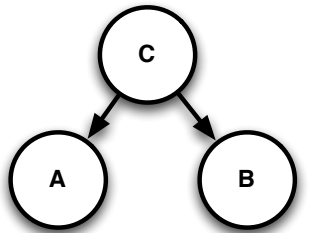
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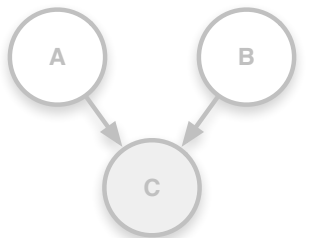
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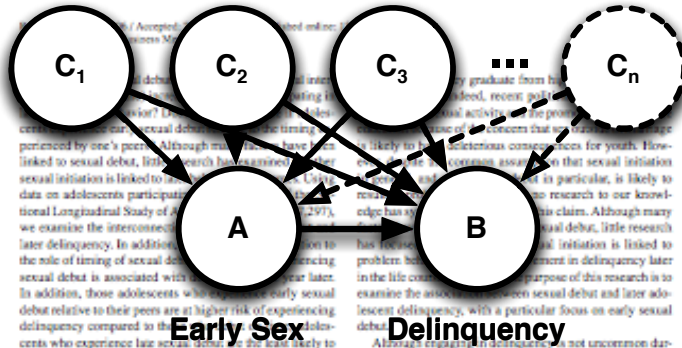


Conditioning on a common effect — A and B share a common effect C , and conditioning on this variable can induce a dependence between A and B .

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Modeling



Introduction

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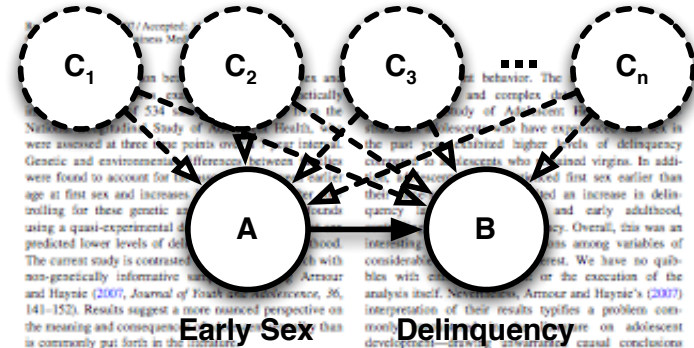
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Keywords Adolescent sexual behavior • First sex •
Sexual debut • Delinquency • Behavior genetics

Introduction

Armour and Haynie recently published a report on "Adolescent sexual debut and later delinquency" in the February 2007 issue of *Journal of Youth and Adolescence*. The authors' stated intent was to examine whether earlier "sexual debut," relative to peers, increases the

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interesting association between variables of delinquency. Overall, this was an interesting finding among variables of delinquency. We have no qualms with either the interpretation or the execution of the analysis itself. Nevertheless, Armour and Haynie's (2007) interpretation of their results typifies a problem common to adolescent developmental research: causal conclusions from non-experimental data.

Armour and Haynie are no doubt well aware of the logical pitfalls of concluding that X causes Y from non-experimental data. Yet, like many researchers, they interpret an epidemiological association between the timing of first sex and delinquency—with little or no qualification—as evidence that early first sex causes later delinquency. For example, they conclude that "the timing of events such as sexual activity has profound consequences" (p. 149) and that "experiencing early or late sexual debut continues to have consequences for delinquent behavior occurring in young adulthood" (p. 150). An alternative explanation for their findings, of course, is that a third variable, either environmental or genetic, is associated with both timing of first sex and later delinquent behavior. That is, the association between early sex and later delinquency reported by Armour and Haynie (2007) could be an artifact of uncontrolled confounds.

(Harden et al. 2007)

Modeling

- Armour and Haynie modeled a large number of potential influences on adolescent behavior.

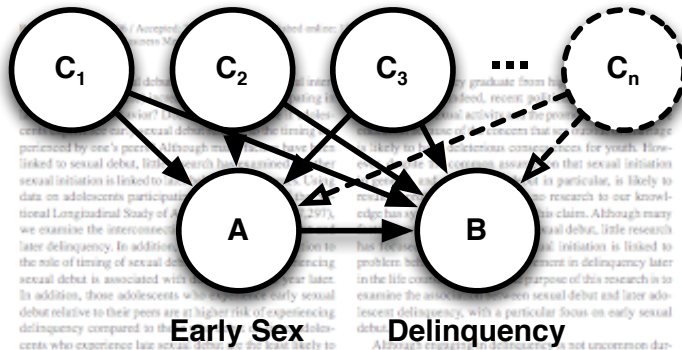
Female		0.065***
A	Receipt of public assistance	0.031
B	P Delinquency at W I	0.151***
C	S Parental support	-0.063
C	D Dating	-0.024
C	I Importance of religion	-0.042
C	S Virginity pledge	-0.206*
S	Relative pubertal status	-0.037

- Even after accounting for these potential causes, a statistical association remained between early sexual activity and delinquency.

Adolescent Sexual Debut and Later Delinquency

Stacy Armour • Dana L. Haynie

Modeling



Early Sex

Delinquency

Introduction

Interest in the timing, prediction, and consequences of sexual initiation continues to garner much research attention. In part, this interest has resulted from the steadily declining age at which adolescents begin having sex and the finding that in the U.S. most adolescents report having had

sexual intercourse by age 18 (Gidycz et al., 2006). In fact, recent research indicates that many adolescents graduate from high school with a history of sexual intercourse (Gidycz et al., 2006). Indeed, recent research has shown that sexual initiation is linked to a host of negative consequences for youth. Flowing from this research, it is clear that sexual initiation, in particular, is likely to have a profound impact on the life course. In fact, research to our knowledge has shown that early sexual debut, relative to peers, is associated with a host of negative consequences for youth. Flowing from this research, it is clear that sexual initiation is linked to a host of negative consequences for youth. Flowing from this research, it is clear that sexual initiation is linked to a host of negative consequences for youth.

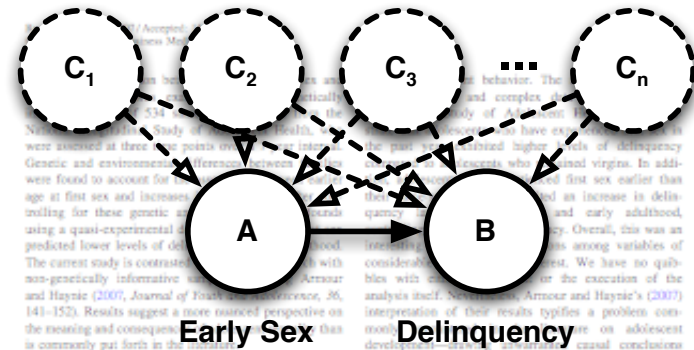
Developmental theory is instrumental in explaining how early sexual initiation can open the doorway to other behaviors. Of primary interest here, developmental theory and life course research suggest that timing of sexual debut is

¹ By sexual debut we refer to transitioning from virgin to non-virgin status based on self-reported information on the experience of sexual intercourse.

(Armour & Haynie 2007)

Rethinking Timing of First Sex and Delinquency

K. Paige Harden • Jane Mendle • Jennifer E. Hill •
Eric Turkheimer • Robert E. Emery



Early Sex

Delinquency

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(Harden et al. 2007)

washingtonpost.com

Study Debunks Theory On Teen Sex, Delinquency

New Analyses Challenging Many Old Assumptions

By Rick Warren
Washington Post
Sunday, Nov. 11, 2007

Researcher says
attention
lose their
to become
established
delinquency
curriculum

There was

Science News

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Early Teen Sex May Not Be A Path To Delinquency, Study Shows

ScienceDaily (Nov. 14, 2007) — A new study by University of Virginia clinical psychologists has found that teens who have sex at an early age may be less inclined to exhibit delinquent behavior in early adulthood than their peers who waited until they were older to have sex. The study also suggests that early sex may play a role in helping these teens develop better social relationships in early adulthood.

See also:

Health & Medicine

- [Teen Health](#)
- [Sexual Health](#)
- [Erectile Dysfunction](#)

Mind & Brain

- [Relationships](#)

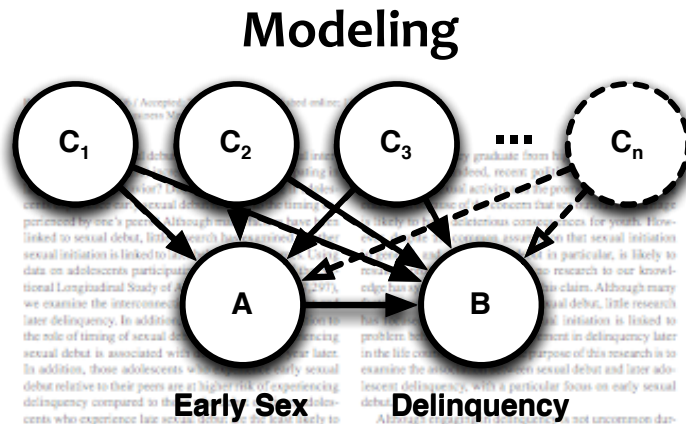
The finding is published in the current online edition of the *Journal of Youth and Adolescence*, and runs counter to most assumptions that relate early teen sex to later drug use, criminality, antisocial behavior and emotional problems. The finding also contradicts parts of a study published earlier this year in the



A new study by University of Virginia clinical psychologists has found that teens who have sex at an early age may be less inclined to exhibit delinquent behavior in early adulthood than their peers who waited until they were older to have sex. (Credit: iStockphoto/Pali Rao)

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Delinquency

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sexual intercourse by age 18 (Gelles & Straub, 2002). In fact, recent research indicates that the average age of sexual initiation has declined from 17.5 years in 1991 to 16.5 years in 2002 (Gelles & Straub, 2002).

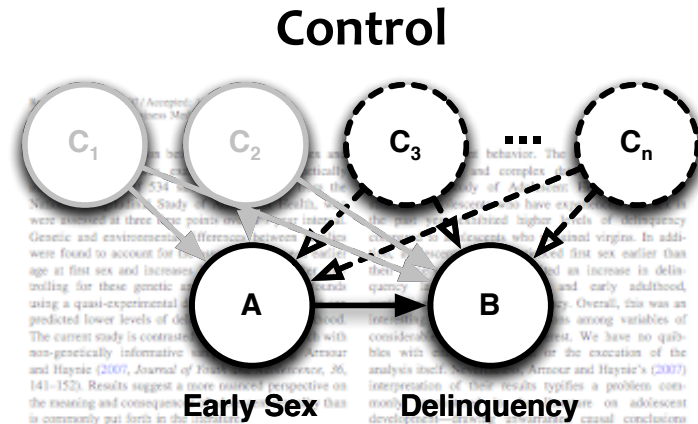
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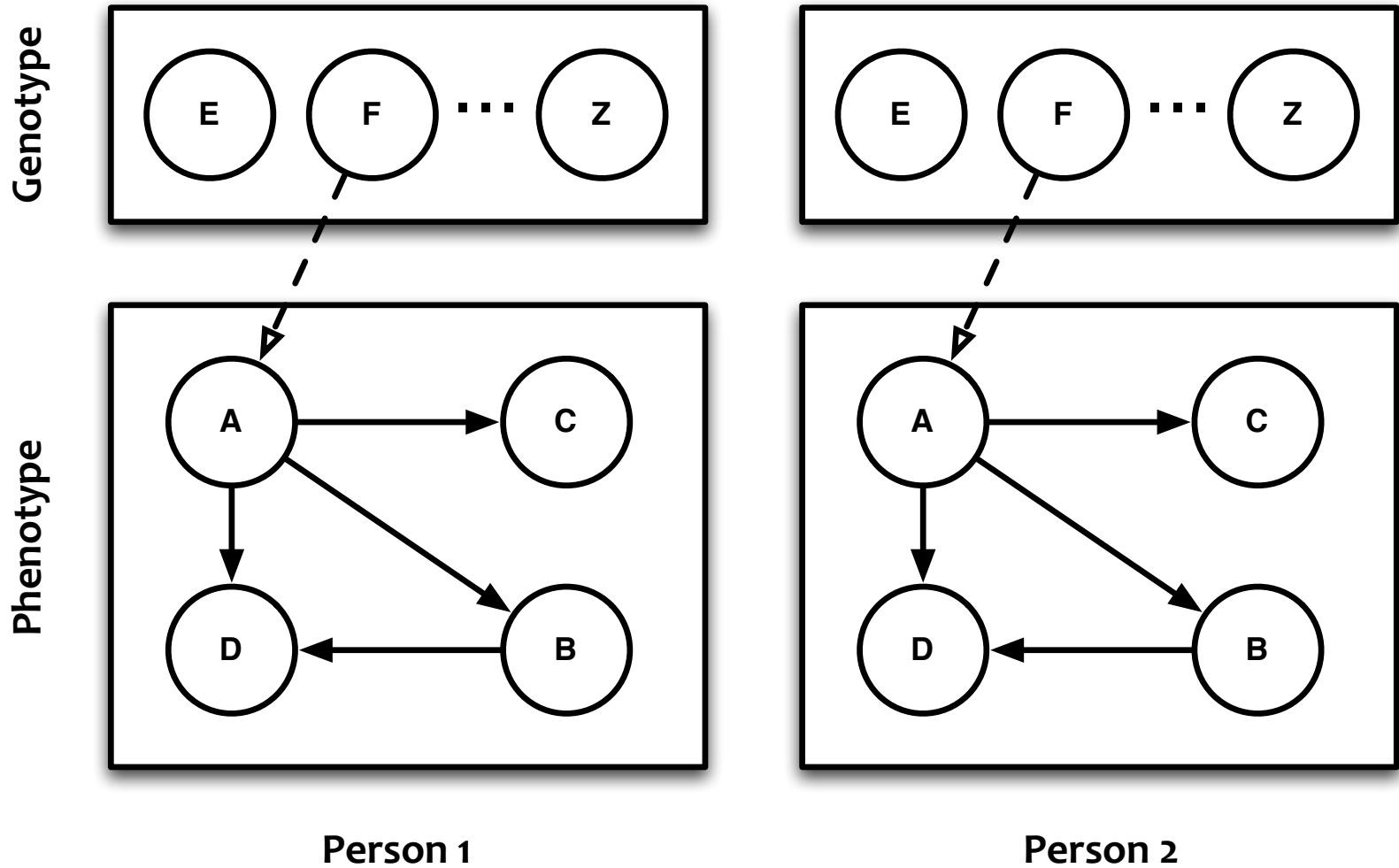
risk of later delinquency. The authors’ findings, based on adolescent developmental data, suggest that earlier sexual debut is associated with later delinquency. However, the authors’ conclusions are based on non-experimental data.

Armour and Haynie are no doubt well aware of the logical pitfalls of concluding that X causes Y from non-experimental data. Yet, like many researchers, they interpret an epidemiological association between the timing of first sex and delinquency—with little or no qualification—as evidence that early first sex causes later delinquency. For example, they conclude that “the timing of events such as sexual activity has profound consequences” (p. 149) and that “experiencing early or late sexual debut continues to have consequences for delinquent behavior occurring in young adulthood” (p. 150). An alternative explanation for their findings, of course, is that a third variable, either environmental or genetic, is associated with both timing of first sex and later delinquent behavior. That is, the association between early sex and later delinquency reported by Armour and Haynie (2007) could be an artifact of uncontrolled confounds.

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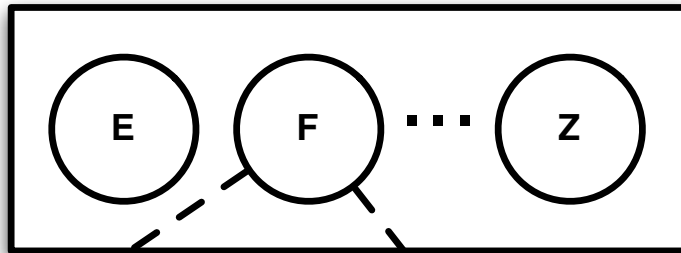
(Harden et al. 2007)

Twin studies

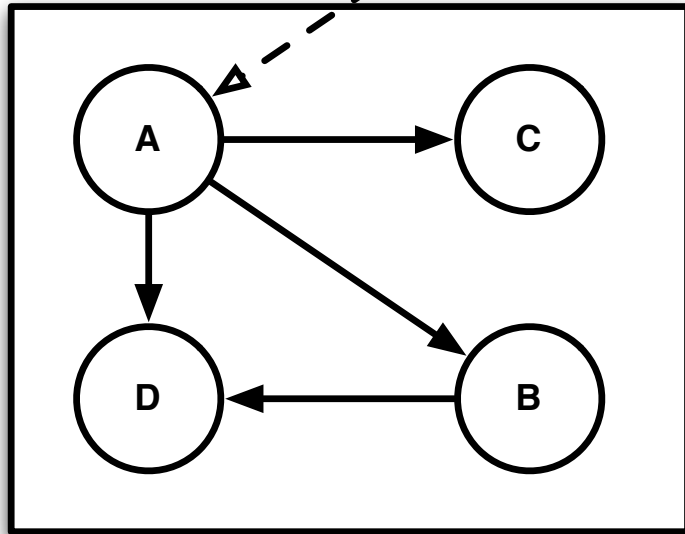


Twin studies

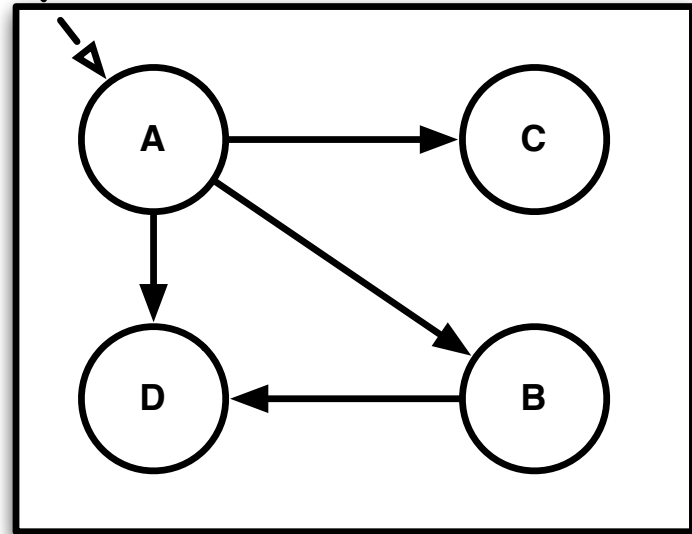
Genotype



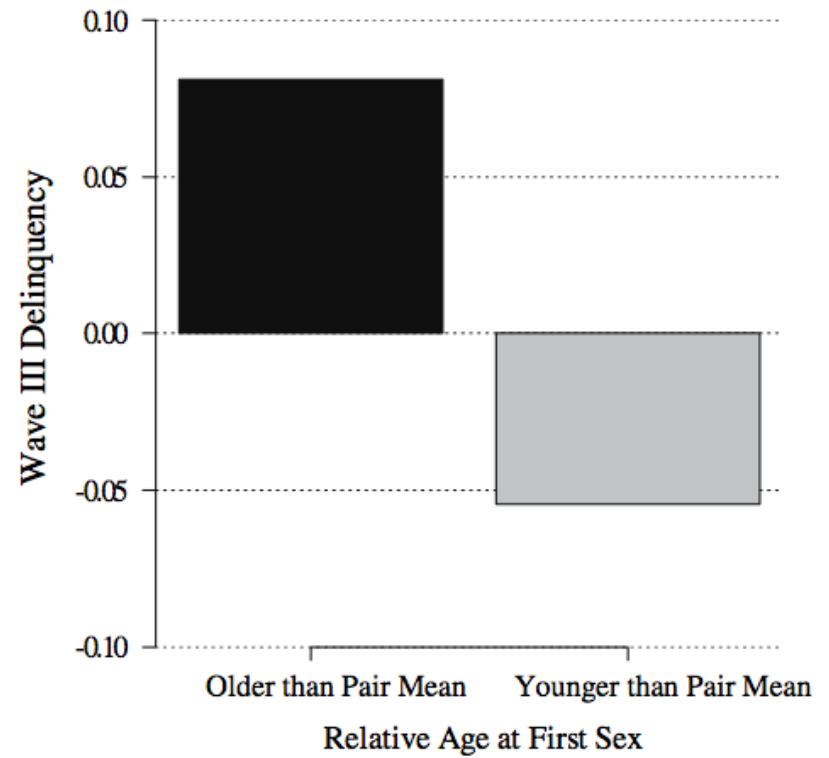
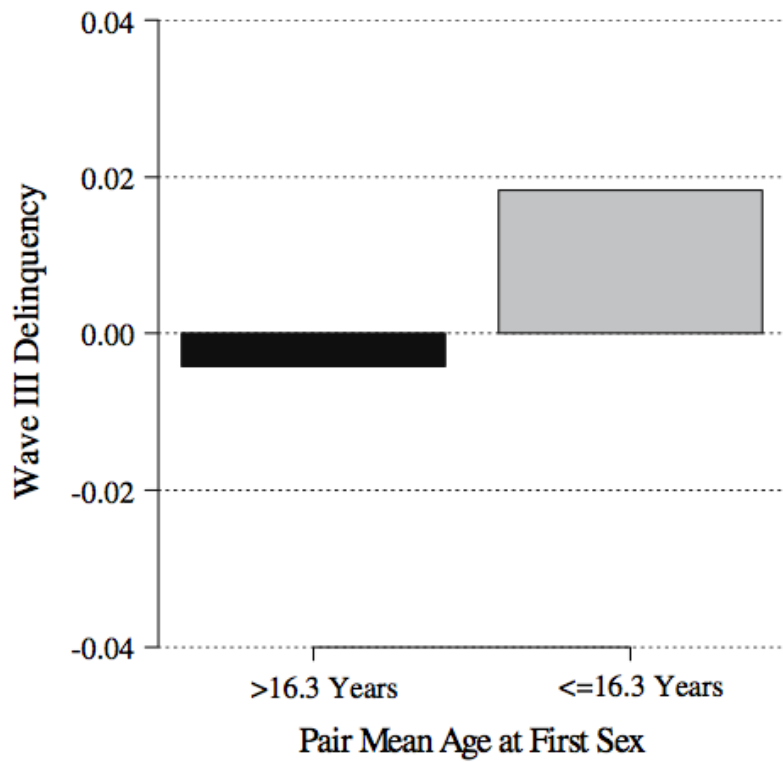
Phenotype



Person 1



Person 2



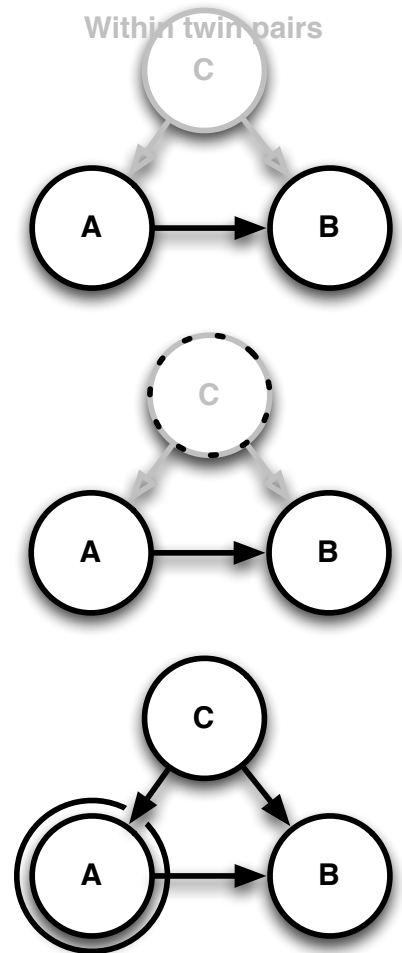
(Hardin et al. 2007)

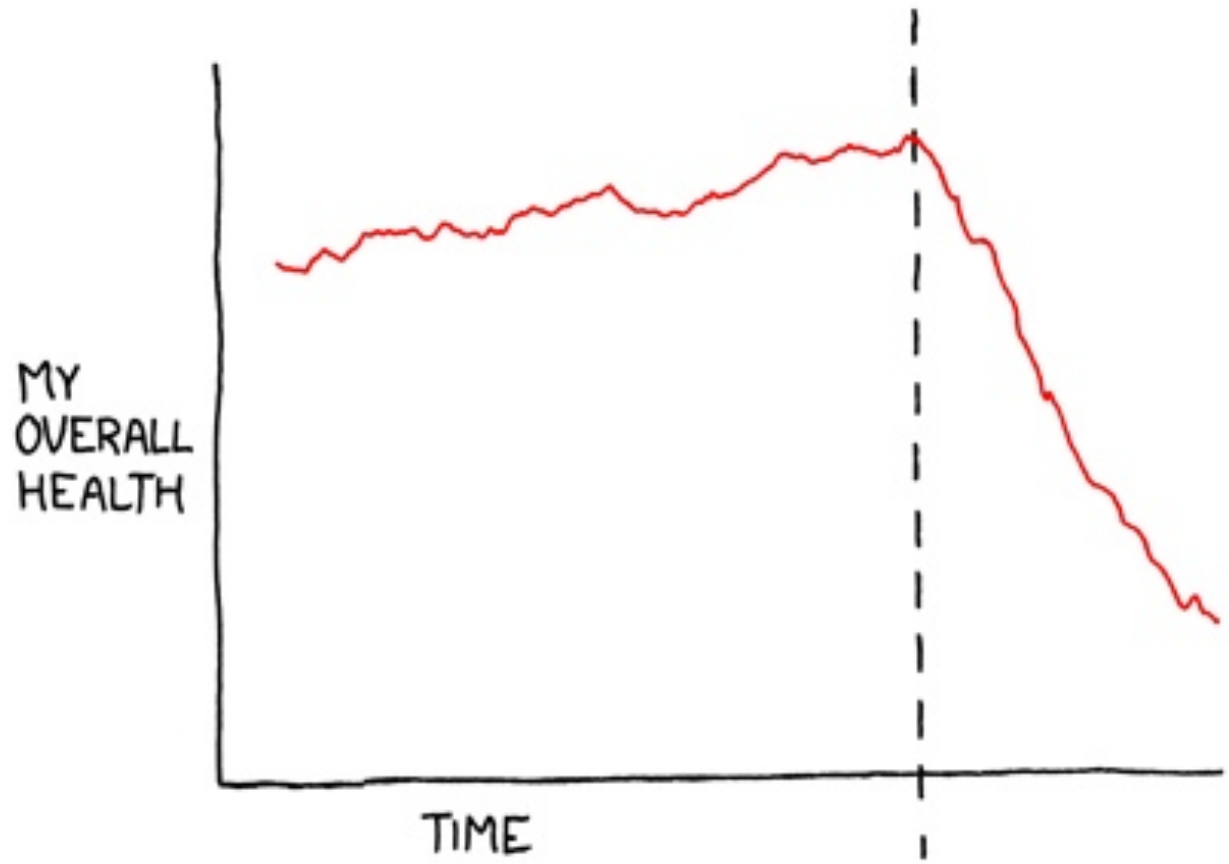
Quasi-experimental Designs

- Quasi-experimental designs (QEDs) are a family of methods for exploiting fortuitous situations in observational data that emulate control and randomization.
- QEDs...
 - ...are *templates* for causal inference...
 - ...that increase *statistical power*...
 - ...by exploiting relations and time...
 - ...to reduce or eliminate the need to model the effects of some variables.

Many types of QEDs

- *Twin design* — Control the value of some potential common causes within specified pairs of instances.
- *Non-equivalent control group design* — Compare temporal responses of treated instances to a control group of similar untreated instances.
- *Regression discontinuity design* — Identify cases where treatment is assigned based on a single variable.
- *and many more...*

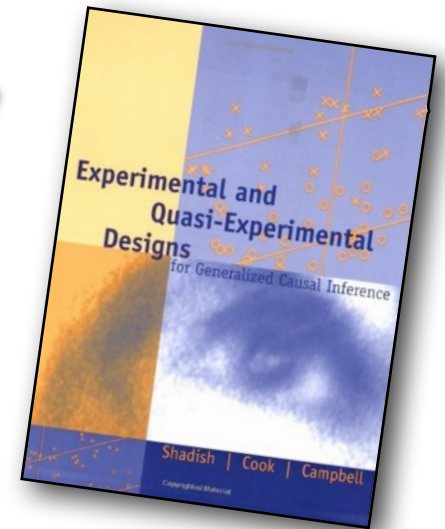




THE DAY I REALIZED
I COULD COOK BACON
WHENEVER I WANTED.

Types of threats to validity

- **Statistical conclusion validity**
Is there a statistical dependence between treatment and outcome?
- **Internal validity**
Does the observed correlation reflect a causal dependence between treatment and outcome?
- **Construct validity**
Do the sampling particulars correspond to the higher-order constructs we wish to examine?
- **External validity**
Does the inferred causal relationship generalize to alternative units, treatment variables, and outcome variables?



Strengths of machine learning methods



- **Statistical conclusion validity**

Is there a statistical dependence between treatment and outcome?



- **Internal validity**

Does the observed correlation reflect a causal dependence between treatment and outcome?



- **Construct validity**

Do the sampling particulars correspond to the higher-order constructs we wish to examine?



- **External validity**

Does the inferred causal relationship generalize to alternative units, treatment variables, and outcome variables?

Current strengths of machine learning

- Methods for analyzing non-traditional data types
Methods for analyzing and modeling text, images, time-series, spatial data, relational data, etc.
- Efficient methods for analyzing massive data
Explicit consideration of time and space complexity of algorithms, approximation methods, etc.
- Non-parametric models
Wide variety of methods for non-parametric probability estimation, classification, ranking, etc.
- Joint models
Directed and undirected graphical models

Research directions for improving relevance

- **Causality**

Focus on methods that learn *causal dependence* rather than *statistical association*

- **External validity**

Focus on methods to assist researchers in *modeling the world* rather than only *modeling the data*

- **Robustness**

Focus on methods that are *robust to variation* in model specification, parameter settings, etc.

Causality

- Many findings in social science have direct implications for social policy, law enforcement, educational practice, management, etc.
- Inferring causality and estimating effect-size is essential to *guiding action* in these domains.
- In contrast, machine learning has traditionally focused on domains well-served by associational models that function as “black boxes.”

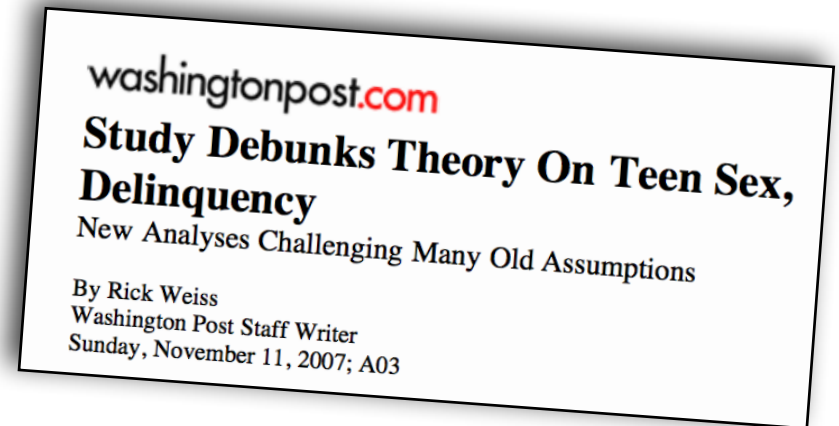


External validity

- In social science, the measured variables often stand in for larger conceptual *constructs* that are the real objects of study.
- Methods that inform human understanding about the existence, causes, and effects of such constructs are particularly useful.
- Many machine learning methods are primarily useful to *model the data* rather than to assist a human analysts to model *the world from which the data are drawn*.

Robustness

- Many social science findings are *actively examined and contested* by both experts and non-experts.
- Methods that are not robust to small changes in data, parameters, or assumptions will quickly become discredited.
- Many existing machine learning applications are fully under the control of developers and don't have to survive in adversarial environments.





Questions?