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# Developmental sources of crash risk in young drivers

J J Arnett

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**Objective:** To outline various sources of crash risk among young drivers that are developmental (age based) factors.

**Methods and Results:** First, a distinction is made between adolescence (ages 10–18) and emerging adulthood (ages 18–25) in order to shed light on the reasons for especially high crash rates among 16–17 year old drivers relative to 18–25 year olds. Then various developmental sources of risk in adolescence are described, including the power of friends, the optimistic bias, and adolescent emotionality. The reasons for especially high crash rates among young males are discussed, with an emphasis on how American ideas about manhood promote driving risks. Finally, a cross national comparison between adolescents in the United States and Denmark shows how developmental risks interact with driving policies.

**Conclusions:** The high crash rates of adolescents relative to emerging adults and of emerging adults relative to older drivers can be explained in part by developmental factors.

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It is well known that driving risks are concentrated especially among the young. Drivers aged 16–24 have higher crash rates than any other age group, including not only minor crashes but also crashes resulting in injuries or fatalities.<sup>1</sup> Scholars studying this topic have concluded that high crash rates among young drivers are due partly to inexperience and partly to what has often been referred to as “maturity”, that is, factors that are age related.<sup>2–5</sup> In other words, there is something about being young that puts young drivers at high risk for crash involvement.

My focus in this paper will be on driving risk in relation to maturity, or what I would prefer to call “developmental” sources of risky driving. What is it about development during the teens and early 20s that explains why crash rates are so high during those age periods? Unfortunately, automobile driving is a topic that has been almost entirely neglected by scholars who study human development during the teens and early 20s. Nevertheless, many of the findings from developmental psychology can be used to cast light on issues related to the problems of young drivers.

Given the limited space available for this paper, I make no attempt to cover the topic comprehensively. For example, I will not discuss risky driving as part of a syndrome that includes several other types of risk behavior, nor will I give a detailed account of the role of parents in moderating young drivers’ risk behavior, which is the topic of a different paper in this issue. Instead, my goal is to draw attention to developmental factors that are often overlooked by scholars studying young drivers and to highlight some of the research questions that should be explored if our knowledge of the developmental basis of young drivers’ high crash risk is to be enlarged.

I will first present a developmental framework for understanding age related distinctions among young drivers. Then I will discuss specific developmental sources of risky driving, including the power of friends, the optimistic bias, and adolescent emotionality. I will also discuss developmental issues related specifically to young males, who have especially high rates of crashes. Finally, I will describe what cross national findings show about how developmental sources of risky driving interact with driving policies.

## DISTINGUISHING ADOLESCENCE FROM EMERGING ADULTHOOD

Rates of crash involvement in the United States are high throughout the 16–24 age period. However, looking year by

year at age and crash involvement, what is most striking is how high rates are for 16 and 17 year olds, even compared to older teens. The crash rate for 17 year olds is 50% higher than that for 18 year olds, and the rate for 16 year olds is two and a half times higher than that for 18 year olds, even though 18 year olds have a higher crash rate than any older age.<sup>6</sup>

Certainly inexperience is part of the explanation for high crash rates among 16–17 year olds, but most scholars agree it is not the whole explanation. We also need to ask what is going on developmentally during this age period. Is there anything happening at ages 16 and 17 that changes dramatically by ages 18 and 19, that could help to explain the steep decline in the crash rate over that span?

In fact, the difference between 16–17 year olds and 18–19 year olds is so stark that they should be considered to be in two separate periods of life. I have argued that a distinction should be made between adolescence, from age 10 to age 18, and emerging adulthood, from age 18 to about age 25, because for most young Americans, life changes in such important ways at age 18.<sup>7</sup> The typical 17 year old attends secondary school and lives in the parents’ household. The typical 19 year old has graduated from secondary school, moved out of the parents’ household, and is involved in any one of many different possible combinations of school and work. Age 18 tends to be the pivotal year when most young people graduate from secondary school, leave their parents’ household, and begin a much different period of their lives. Emerging adulthood is characterized by a high level of freedom, independence, and instability. It is a period in which young people are gradually moving toward full adulthood as they learn to be self sufficient and take on the responsibilities of adult life.

The distinction between adolescence and emerging adulthood can be usefully applied to young drivers. It focuses our attention on the differences between young drivers who are 16–17 years old and those who are 18–25 years old. (It is striking that so many studies of young drivers use the age interval of 16–19 or 16–20 in describing driving patterns. In developmental terms this interval makes little sense.) It leads us to possible developmental sources for the exceptionally

**Abbreviations:** ESM, experience sampling method; FARS, Fatality Analysis Reporting System; MPH, miles per hour

high crash rates of 16–17 year olds. It also illuminates possible developmental explanations for why 18–25 year olds have higher crash rates than any older age group.

### THE POWER OF FRIENDS

One of the differences between adolescence and emerging adulthood is that nearly all adolescents attend secondary school, but most emerging adults leave high school by age 18 and move on to diverse combinations of school and work. Is there something about being in high school that could promote risky driving and higher crash rates? One notable feature of high school is that it is an environment intensely oriented around peers and friends, both for better and for worse.<sup>8,9</sup> What many adolescents like least about high school is that it is a place where they are subject to the critical judgments of their peers in terms of how they look, how they act, and how popular (or unpopular) they are. But what they like most about high school is that it is a place where they see their friends, and form cliques (small, closely knit groups of friends) that are the basis for their leisure lives outside of school.

It is in the social dynamics of these friendship cliques that part of the answer may be found to the high crash rates of 16 and 17 year olds. One piece of evidence that supports the importance of friends is that crash rates are especially high for teens when there are two or more passengers in the car, especially when they are driving at night.<sup>2,3</sup> For example, a 1998 study by Preusser and colleagues,<sup>10</sup> using national data from the Fatality Analysis Reporting System (FARS) showed that the risk of fatal crash involvement was especially high for teenage drivers traveling with two or more passengers. Similarly, a study of drivers in Ontario showed fatal and non-fatal crashes were especially high for 16–19 year olds driving at night, on weekends, and with passengers.<sup>11</sup> In both studies, the presence of passengers made crash risk higher only for younger drivers. In the Preusser *et al* study,<sup>10</sup> the presence of passengers was actually related to reduced crash risk for drivers over 30.

A British study<sup>12</sup> suggests that the gender of the passengers may make an important difference. The presence of young female passengers was associated with safer driving for young men, but the presence of young male passengers was associated with dangerous driving (for example, higher speed, smaller following distance) for both young male and young female drivers.

What is going on among these groups of teen friends in a car together that promotes crashes? It is easy to imagine a group of high school friends driving around together on a weekend evening. They are in that state of elation that adolescent friends often generate when they are together. But they are a little bored, too, and looking for something to do. They try a few places and not much is happening, but they are in a car, they can make something happen. The driver decides to show off how fast he can drive, or how quickly he can pass the car in front of him; perhaps his friends urge him on, perhaps they even initiate it: "Let's see how fast this baby can go!" Maybe they have all been drinking and/or using drugs. He begins driving recklessly, and a crash results. Or maybe it just happens inadvertently, maybe they are all talking and laughing, and the driver is trying to join in and gets distracted, does not see the red light, or does not see the car coming the other way, and again a crash results.

Another developmentally relevant aspect of high school friends in cars is how a car may be utilized as a setting where they can be together away from the monitoring of their parents or other adults. One of the things that distinguishes adolescents from emerging adults is that most adolescents live at home whereas most emerging adults do not. As studies by developmental psychologists have shown, by the time they reach high school age, most adolescents do not enjoy being

around their parents.<sup>8</sup> In contrast, they experience their happiest moods around their friends.<sup>8,9</sup> They prefer not to have their parents present when they are with their friends, so where can they go to be just around their friends? School is one place, as I mentioned, or they can also hang out somewhere such as a shopping mall or a fast food restaurant.

But they can also simply ride around in a car. The transportation function of the car then becomes secondary to its social function as a place where adolescent friends can be together independently of their parents. For most young people this social function of cars becomes less relevant after age 18, when most of them move out of their parents' household. Once they move out, they can simply invite friends over so they no longer need the car to serve as a social setting. It could be, then, that one of the reasons for higher crash rates among 16–17 year olds is that they spend more time in cars with friends and use their cars more for purposes that promote their social interactions but are inimical to safe driving.

We have, so far, virtually no information about the phenomenology of this situation, of high school friends riding around in a car together, and this is a crucial gap in our knowledge. What goes on? What does it feel like? What are they doing that may make them at higher risk for a crash? We need to interview them to find out. It would also be helpful to interview adolescents who had been involved in a crash under these circumstances, to have them detail the circumstances of the social interactions within the car that may have led to the crash. Furthermore, because crash rates are so much higher at age 16 than age 17, there is a need for studies that explore developmental differences between these two ages. Currently, studies of adolescent development nearly always lump 16 and 17 year olds into one group, but examining the two ages separately is necessary for understanding the especially high crash rates of 16 year olds.

### THE OPTIMISTIC BIAS

Another possible developmental explanation for higher crash rates among teens involves risk perception. Especially important here is the concept of optimistic bias, which is the tendency to view the likelihood of negative events as higher for others than for oneself. A number of studies have found that younger drivers view their risk of a crash resulting from various dangerous driving behaviors as lower than do older drivers.<sup>13–15</sup> Young drivers may overestimate their driving skill, and this may be one of the factors that lead them to take driving risks that older drivers would avoid.

However, there is a striking limitation in the literature on this topic. Virtually all of the studies compare emerging adults—often college students—to older drivers. Consequently, they fail to explain the dramatic drop in crash rates that takes place between adolescence and emerging adulthood. No studies of optimistic bias and driving compare these two age groups; no study even includes drivers under age 18. However, given that emerging adult drivers have been consistently shown to have a greater optimistic bias than older drivers, it would be reasonable to hypothesize that adolescent drivers have an optimistic bias that is even greater. This is a question that certainly merits investigation.

### ADOLESCENT EMOTIONALITY

Another part of the developmental explanation for why crash rates are so high among 16–17 year olds may be the emotionality of adolescence. Although many scholars have disputed the stereotype that adolescence is inevitably a time of turmoil, there is good evidence that adolescents have mood swings, especially toward the negative end, that are more extreme than either preadolescent children or adults.<sup>16</sup> The most interesting and persuasive line of research in this area uses a technique known as the experience sampling method (ESM).<sup>8</sup> In studies using ESM, participants wear watches with beepers

that are timed to go off about 12 times a day at random intervals. Each time they are beeped, they record a variety of information about what they were experiencing at that moment, including where they were, what they were doing, whom they were with, and their emotional state. Studies using this method have found that adolescents report more extremes of emotion than either preadolescent children or adults. They more often report being "very unhappy" and also more often report being "very happy".

Research in this area has focused on the 9–15 age range, so unfortunately there are no ESM data that directly relate emotional volatility to adolescent driving. However, it seems likely that this connection exists for 16–17 year olds. Studies have reported that young drivers are more likely than older drivers to use driving to "blow off steam" or otherwise express negative emotions. It could be that extreme positive emotions, too, find expression in risky driving. The ESM studies describe the elation that adolescent friends feel when they are together without adults present, especially on weekend evenings.<sup>17</sup> It could be that when this mutual elation takes place in a car it is both distracting to the driver and may goad the driver into taking risks in order to amuse or impress friends.

It also seems likely that extreme emotions decline after high school, following the transition from adolescence to emerging adulthood, although at this point we lack data comparing the two periods. But we do know from the ESM studies that for adolescents, their extreme moods, both positive and negative, are often rooted in their experiences with their peers. Once they leave the peer pressure cooker of high school, it may be that extreme emotions abate, and consequently, older teenagers become less likely to use driving to express extreme emotions.

### MALENESS AND RISKY DRIVING

As many scholars have noted, high crash rates among young drivers are especially a problem among males.<sup>13</sup> Although some research indicates that females are closing the gap, young males still have substantially higher rates of minor crashes, crashes resulting in injuries, and fatal crashes. What is it about being not only young but male that promotes risky driving? Some of the developmental sources of this sex difference are well established. In males, levels of testosterone, the sex hormone most clearly related to aggressiveness, are 20 times higher by the mid-teens than they were prior to puberty, compared to a relatively modest fourfold rise among females.<sup>14</sup> A higher propensity for aggression is expressed in many ways by young males, such as physical fights, violent crimes of all types, and aggressive driving behavior.<sup>19–21</sup> More aggressive driving certainly contributes to the higher crash rates of young males.<sup>22–24</sup>

A related developmental influence is sensation seeking, which is the degree of a person's propensity to seek out novel and intense stimulation. Sensation seeking has been found consistently to be higher among young males than among young females,<sup>25–26</sup> and sensation seeking is in turn related to driving in risky ways.<sup>3, 27–28</sup> Sensation seeking leads some young men not just to accept risk in the course of driving, but also to seek it out. In the high school environment, high sensation seeking boys may form friendship cliques in which they stoke each other's tendencies for driving risks by the way they approve and esteem risky driving behaviors.

One other developmental source for the particularly high driving risk of young males is subtler, but it may be the most important of all. In American society, reaching manhood is linked in some dangerous ways with risky driving. As Niki Harre has observed,<sup>3</sup> the risk seeking tendencies of young males are "propped up with an entire social system of norms and media images that equate fast driving and 'skillful' maneuvers with masculinity, adulthood, and peer group approval" (p. 218). Courage and the willingness to take risks in

the face of danger is a requirement of manhood in many cultures, but in American society it often takes the unfortunately deadly form of dangerous driving.

The association between manliness and risky driving has been frequently portrayed in popular culture. In the 1950s there was James Dean and his friends playing "chicken" in *Rebel Without a Cause*, with his racing opponent hurtling off a cliff to his death. Dean himself, in real life, died young in a fiery car crash. In the 1960s came James Bond, then and ever since an icon of masculinity, with all Bond movies featuring at least one reckless car chase scene. Bond movies established a model for "action" movies, and most of them still feature the *de rigueur* car chase scene. The recent movie *The Fast and the Furious* is among the latest in this genre.

Audiences for such movies are predominantly adolescent boys and emerging adult men. But we still do not know much about the meaning of these popular cultural portrayals to young males. We can make observations about the popularity of depictions of reckless driving in popular culture, but we also need to investigate the attitudes and beliefs of young male drivers with regard to the intersection of manliness and risky driving, and their accounts of how media stimuli promote this combination.

### THE GROWING IMPORTANCE OF RESPONSIBILITY

Emerging adulthood is an age of being in between, of feeling on the way to adulthood but not there yet. I have conducted numerous studies of how people define what it means to be an adult, and consistently on top in importance is having a sense of *responsibility*.<sup>29–31</sup> Mainly, this means taking responsibility for yourself, learning to be self sufficient, but for most people it also means cultivating a sense of responsibility toward others. The item "become less self centered, develop greater consideration for others" is endorsed as necessary for adulthood by the great majority of emerging adults, over 80% in my studies. Similarly, over 70% indicate that "avoid drunk driving" is one of the necessary criteria for adulthood.

Perhaps we have here part of the developmental explanation for the decline in the crash rate after age 18. It may be that after age 18, young drivers become more conscious not just of how their risky driving may put themselves at risk but also how it may jeopardize others. The steep decline in crash rates from age 16 through the 20s is all the more striking when we consider that many other types of risk behavior are in fact increasing during this period,<sup>32</sup> such as the use of alcohol and other substances.

What distinguishes the use of alcohol and other substances from risky driving is that substance use by itself usually puts only the user at risk, whereas risky driving poses risks not only to the self but also to others. As young people move through emerging adulthood they become gradually less self centered and more intent on being considerate toward others as part of progressing toward adult status. This may include avoiding risky driving practices that put others in danger. But the development of this consideration for others, like the attainment of adulthood itself, occurs only gradually from 18 through the mid-20s, and consequently crash rates remain relatively high until the 30s.

### FREEDOM AND RISK IN EMERGING ADULTHOOD

So far I have discussed a variety of developmental factors that may make adolescents at greater risk for crashes than emerging adults. However, even emerging adults have higher crash rates than do older adults. In the United States, crash rates are more than two times higher for 20–24 year olds as they are for 30–34 year olds, both for fatal crashes and for all crashes.<sup>6</sup> Now that we have examined some developmental reasons why crash rates are higher in adolescence than in emerging adulthood, we also need to ask why crash rates are higher in emerging adulthood than for older adults.

**Table 1** Rates of risky vehicle use by Danish and American adolescents

Behavior	At least once in past year (%)	
	Danish	American
Driving car >80 MPH	20	79
Driving car >20 MPH over speed limit	22	85
Driving car while intoxicated	7	26
Riding moped while intoxicated	20	0
Riding bicycle while intoxicated	78	3

MPH, miles per hour.

For the first two items, MPH were converted to kilometers for the Danish adolescents.

Danish adolescents,  $n = 100$  (45 boys, 55 girls); American adolescents,  $n = 133$  (63 boys, 70 girls).

The freedom that distinguishes emerging adulthood may be a developmental source for their higher crash rates when compared to those of older adults. Most emerging adults move out of their parents' home by age 18 or 19, and most of them do not enter marriage and parenthood until at least their late 20s. It is this state of being in between definite social roles that is in part what defines emerging adulthood. This freedom is valuable in some ways, because it provides emerging adults with the opportunity to try out various possible paths in love, education, and work.

However, their freedom also puts them at risk. Leaving home means that their parents are no longer present to monitor and perhaps restrict their driving behavior. They no longer have a parent imposed curfew. They no longer have to worry whether a parent may smell alcohol on their breath when they return home on a weekend evening. Research shows that parental restrictions make a difference in the driving behavior of adolescents,<sup>33</sup> and it seems likely that the lack of such restrictions contributes to driving risk in emerging adulthood.

Crash rates plateau after age 30 and remain stable through the 60s. This can be explained in terms of the end of emerging adulthood and the entry into full adulthood. Specifically, by age 30 the great majority of people have entered the roles of marriage and parenthood. Studies of substance use and criminal behavior have found that entering these roles sharply reduces the extent to which people engage in these behaviors.<sup>32,34</sup> It seems likely that studies of driving behavior would yield similar results, that the obligations and restrictions of marriage and parenthood act to reduce risky driving and hence crash rates. Once emerging adults become full adults, they leave behind the childish ways of their youth, including a variety of types of risk behavior.

### CROSS NATIONAL DIFFERENCES

High crash rates among young drivers are a problem around the world, but especially in the United States. We need to ask, then, not just what is it about young drivers that makes them at higher risk for crashes, but what is it about American society that leads young drivers to be especially at risk. More specifically, in what ways do the developmental sources of risky driving described above interact with state and national policies in the US to produce higher crash rates among young drivers?

Perhaps the most obvious and concrete difference between the US and other countries with respect to young drivers is the relatively low age of licensure in the US. In most American states, 16 is the minimum age for obtaining a driver's license, but in most other industrialized countries the minimum age is 18.<sup>2</sup> Thus, other countries eliminate entirely the problem of high crash risk among 16 and 17 year olds by not allowing them to drive.

Even for young people who have reached the legal driving age, driving has a different function and meaning in the United States than it does in other countries. Cars are more accessible for young Americans. The US is wealthier and cars are cheaper because they are not as heavily taxed. Public transportation is less extensive in the US, and distances from one place to another often longer. There is also, I think, a sense of entitlement to an automobile in the United States, a sense that by the time you are 16 years old you *should* have a car or at least regular access to one, that without one you are not really a legitimate member of American society, or at least of the American middle class. However, we lack data on this. There is a great need for studies that explore the beliefs and attitudes that need Americans—especially young Americans—have about the meaning, value, and functions of driving.

The consequences of national policies for risky driving among young people are evident in research I have done comparing young people in Denmark and the United States.<sup>35,36</sup> Denmark is about as different a country from the United States as you will find with respect to its driving policies. Public transportation is cheap, reliable, safe, and ubiquitous. Bike paths line nearly every road throughout the country. The minimum driving age is 18. Even after age 18, car ownership or even car access among young people is not the norm, because cars are extremely expensive due to high taxes and because there is no real need for owning a car due to the availability of public transportation. As a result of these policies, risky driving among the young is relatively rare in Denmark.

In our study, only 46% of 18 year old Danes had driven a car *at all* in the past year. Only 13% of 17–18 year olds affirmed that a car was needed to get around in their community, compared to 91% of American 17–18 year olds. As table 1 shows, rates of various types of risky driving behavior were much lower for Danish 17–18 year olds than for Americans. They were much less likely to drive an automobile while intoxicated or drive at high speeds. The table also shows that Danish 17–18 year olds were far more likely than American 17–18 year olds to ride a moped or a bicycle while intoxicated. Moped riding is legal at age 16, and Danish adolescents typically use bicycles as their main mode of transportation. So, Danish 17–18 year olds also ride vehicles in some risky ways, but the vehicle in which they take their risks is a far less lethal one than for the Americans.

### CONCLUSION

The high crash rates of adolescents relative to emerging adults and of emerging adults relative to older drivers can be explained in part by developmental factors. However, thus far the contribution of the developmental literature to understanding crash risks in young drivers has been mostly indirect. Potentially fruitful areas for investigation include:

- Qualitative studies on the phenomenology of adolescent friends using the car for social and leisure purposes, including studies of friends involved in crashes and studies of high sensation seeking friendship cliques
- Studies comparing the optimistic bias in 16–17 year olds and emerging adults
- Studies of adolescent emotionality and driver behavior using ESM
- Studies of conceptions of manhood in relation to driving behavior, including attitudes toward associations between manliness and driving risk in popular culture
- Studies of how emerging adults' views of what it means to be an adult may include learning to drive responsibly, and how marriage and parenthood may result in a decline in risky driving
- Cross national studies of attitudes toward the rights and responsibilities of young drivers, including studies of how young people view the meaning and functions of driving

The study of developmental sources of crash risk among young drivers carries great potential for adding to our understanding of the basis of young drivers' high crash rates. This potential is, so far, largely untapped, but it need not remain that way.

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## DISCUSSION PAPER

Arnett suggests the need for a developmental perspective in research on adolescent driving. Specifically, he argues that there are developmental sources of risk not addressed by the current literature that would further our understanding of crash risk among young drivers. He first outlines a developmental framework for understanding age related distinctions, and then highlights specific developmental sources of risky driving including power of friends, optimistic bias, and adolescent emotionality. He concludes with some issues about male gender and cross national studies. In this discussion, we briefly comment on these areas and propose some overall questions and research directions that investigators and policy makers may want to consider as we attempt to further understand and reduce the negative outcomes associated with driving during adolescence and young adulthood.

## DEVELOPMENTAL FRAMEWORK

In the developmental framework section, Arnett raises one of the most critical issues in attempting to understand this period of the life cycle—age. Although related, chronological age and development are not the same. Yet, investigations of both health promoting and damaging behaviors during the second decade of life often confuse these variables. In fact, most studies do not provide a rationale for choosing or studying a specific age group. Many samples are chosen by convenience or from extant national data sets where the age cohorts are chosen with little thought about development. None of the current national data sets provide policy makers with a true picture of mortality as it relates to the true driving behavior of young people, as these data are typically grouped into age ranges such as 15–19, 20–24, 15–24, and 14–44; none of these age groupings make sense given the variation in emotional, psychosocial, and environmental factors within these groups.

The argument that Arnett makes about distinguishing adolescence from young adulthood when understanding driving behaviors is an important one. This argument can be extended to include not only the need to address other areas of development that might influence risk of injury or fatality while driving, but also the need to examine developmental factors including cognitive abilities that might influence the acquisition of driving skill and norms among drivers of different ages that may, in turn, have policy implications.

## POWER OF FRIENDS

Arnett makes a strong case for the importance of friends and the role that friends may play in driving with resultant crash or injury. He argues that cliques play a critical role in the development of young people and provide the social norms

during early/middle adolescence. He then suggests that since crashes are more likely to occur when there are other teens in the cars, these adolescent cliques are associated with higher crash rates during adolescence compared to young adulthood. Although it makes sense that crash rates are higher when multiple passengers are in the car, presumably because these passengers can distract from one's driving ability, we need to clarify whether the passengers are members of their cliques and associated networks or whether they are other individuals, possibly even older than the friends in their cliques.

Arnett makes the assumption that developmental needs, importance of friends, and ways of socializing rapidly shift from late adolescence to early adulthood, but we do not have longitudinal data that support this developmental trajectory. Some of the examples that Arnett cites regarding the media and boredom are speculative and provocative, and more research is needed in this area. As he states, "we have, so far, no information about the phenomenology of this situation, of high school friends riding around in a car together, and this is a crucial gap in our knowledge".

### OPTIMISTIC BIAS

Arnett correctly points out that there may be an association between risk perceptions and higher crash rates. There is much theory and speculation that adolescents engage in risky behavior because, compared to adults, they are incompetent at judging risks or making decisions and they believe they are invulnerable to harm. However, empirical tests of these assumptions yield mixed results, largely due to differences in methodology.<sup>1</sup> In work conducted by our group on risk perception, we found that adolescents perceived risks around a number of behaviors as being either high or very high.<sup>2,3</sup> More recent work indicates that adolescents actually perceived greater behavior related risk than did adults.<sup>4</sup> If young drivers underestimate their risks regarding their skills (there appears to be some evidence of this from the data presented by Arnett), driving may differ from other risky behaviors. Although there has been cross sectional research on the relation between risk perceptions and behavior, few longitudinal studies have been conducted to determine whether risk perceptions actually motivate behavior or are instead reflective of one's experiences with behaviors and outcomes. Even fewer longitudinal studies have specifically focused on adolescent driving behavior.

We need to be certain that risk perception and optimistic bias are not confused. Risk perception is an estimate of the likelihood that a given behavior will result in a given negative outcome. Optimistic bias is the perception that one is less likely to experience a negative outcome than is someone else. One may have an optimistic bias but still think that a referent is high risk. When one looks specifically at optimistic bias, there would be no reason to assume that late adolescents would differ dramatically from emerging adults. In fact, our recent work suggests that adults are more optimistic than adolescents across a number of areas. As Arnett stated, there are major limitations with this literature and more research is needed related to adolescent driving. Arnett also raises the importance of perspective taking and its potential relation with driving. One's ability to take another's perspective, as well as other developmental tasks such as consideration of future consequences and impulse control, may also play an important role in adolescents' risk perceptions, decision making, and subsequent driving risk behavior.

### EMOTIONALITY

The importance of emotionality as part of the developmental explanation for high rates of crashes among late adolescents is intriguing and should be researched. As Arnett points out, the experience sampling method (ESM) work has only

sampled adolescents between 9 and 15 years of age. The question remains, do adolescents who are more prone to experience mood swings develop into riskier, less attentive, or just plain dangerous drivers? It would also be helpful to know the role that environment plays in modulating these risks. We know from research in cardiovascular reactivity that positive life experiences appear to modulate exaggerated cardiovascular responses and that adolescents with this profile engage in less risk behaviors.<sup>5</sup> It is not clear how positive life experiences might modulate emotionality and influence the crash risk during late adolescence and early adulthood.

### HIGH RISK FOR MALES

Being male is more dangerous than being female from the perspective of mortality, and this is not unique to adolescence: negative outcomes occur long before adolescence. There is much evidence that indicates that males die earlier than do females, beginning shortly after birth and increasing throughout childhood to young adulthood. After age 1, boys die at a higher rate than do girls for all causes, and especially from injuries and motor vehicular crashes.<sup>6</sup> This raises some basic questions: Are males from an early age placed in more adverse situations? Are they encouraged early in life to do more dangerous things such as drive more dangerously, as portrayed through the media?

### CROSS NATIONAL COMPARISON

Arnett uses data from a study of Danish and US youth on driving. As he points out, there is a significant difference in exposure to cars among Danish youth, which is reflected in the low percentages of Danish youth who engage in excessive speed or drinking and driving a car when compared to US youth. However, Danish youth do ride bicycles while intoxicated, bicycles being their main means of transportation. This cross national comparison raises some interesting questions. Even though the positive outcomes associated with driving policies are apparent from the data, there is a similar outcome: Danish youth drive their bicycles at similar rates of intoxication as US youth drive their cars. The Danish experiment speaks to the critical importance of environment (culture and public policy) modulating the risk of vehicle use, but also may speak to something universal about youth needing to take risks.

### SUMMARY

Arnett has identified an area of research that has been neglected by developmental scholars and transportation researchers alike. His paper provides a road map for where we need to develop further understanding as we develop policies and intervention programs in the area of young drivers. There is much more research to be conducted in this area, using both cross sectional and longitudinal methodology with diverse samples. One large, existing longitudinal data set that has yet to be fully tapped into, especially in the driving arena, is the National Longitudinal Study on Adolescent Health (Add Health).<sup>7</sup> This data set provides us with a stratified, nationally representative sample of adolescents and their social context. It includes questions that address the area of driving and other risky behaviors with onset during adolescence, health promoting behaviors queried both during and prior to adolescence, and contextual variables including SES, parental monitoring, and school and community characteristics. Analyzing these data may enable us to understand more fully the contextual factors that are associated with risky driving and the role that positive behaviors may play in modulating risk at different ages.

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