Kurzbeitrag

Bicycle accidents among teenagers: Examining the role of executive functions

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1 A young population at risk for bicycle accidents

A 13-year-old was admitted to hospital, blood running from his face. Tom had an accident with his bicycle on his way back home from school with his friends. What happened? He can ride a bicycle. He knows the rules. Still, the ambulance is taking him to the hospital. Tom was riding his bicycle downhill – around a corner – hands free – while standing – without a helmet. During this stunt he wanted to grab the handlebar but missed. The bicycle swayed and Tom smashed against the wall of an underpass. ‘You only live once’ (YOLO) say teenagers. Sometimes they do not realize how true this is. Tom was lucky: a few stitches on the forehead and a scar that will last, a broken shoulder bone, and an injured knee.

Kids between 10 and 14 years are more likely to be involved in bicycle accidents than any other age group in Germany (cf. *Statistisches Bundesamt* 2012). Of course, there is effort to reduce the risk of bicycle accidents. At the end of the fourth grade, most children take part in a cycling training provided by their school. The training consists of a theoretical part in which children learn the basic traffic rules as well as a practical part where they train motor skills necessary for cycling (e.g. cycling through a course of obstacles). The training ends with a test on the learned competencies. Some fail but most children pass the test and receive confirmation that they are allowed to use their bicycle in traffic autonomously. However, just after the training accident rates rise.

Several factors are discussed to cause the high accident rates of 10- to 14-year-olds. Compared to adults, children and adolescents have slower reaction times (cf. *Feenstra/Ruiter/Kok* 2012; *Plumert/Kearney/Cremer* 2004), shorter attention spans, and show deficits in perspective taking, risk awareness, and motor skills (cf. *Limbourg/Flade/ Schönharting* 2003). As a result, kids might not react as fast when confronted with an unexpected event, have trouble to anticipate the behavior of others, and experience difficulties performing complex motor behaviors like the quick over the shoulder-glance before taking a turn while indicating.

However, there is one factor that most studies and reviews ascribe a pivotal role in the increase in accident rates of this age group: increased risk-taking (cf. *Steinberg* 2004, 2007). Increased risk-taking is believed to be crucial for the development of autonomy during adolescence. Compared to adults, children reaching puberty show a heightened activity in the reward circuitry of the brain (ventral striatum (VS) and orbifrontal cortex)

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when engaging in risky behavior – an effect that is even more evident in the company of peers (cf. *Chein* et al. 2011). The reward circuitry contributes to learning long-term functional strategies in a variety of settings. Another important structure of the brain involved in behavior, the prefrontal cortex (PFC), also matures considerably during puberty but is fully developed only in the early twenties. The PFC is a core structure for behavior and emotion regulation, which is accomplished via a group of top-down mental processes, i.e. the executive functions (EF) (cf. *Blakemore/Choudhury* 2006). Empirical evidence suggests that there are three core EFs (e.g. *Lehto* et al. 2003; *Miyake* et al. 2000): inhibition, working memory, and cognitive flexibility. Inhibition refers to processes in which an impulse has to be suppressed in order to reach a given goal. Working memory is necessary for mental operations, such as planning and decision-making. Cognitive flexibility helps adapting to new situations, changes in demands, and is also closely linked to creativity (cf. *Diamond* 2013). Both systems, the reward circuitry and the PFC, work together in an interactive fashion and contribute to decision-making. Due to its later maturation, however, the PFC may not yet be capable to regulate the heightened activity in the reward circuitry via the EF during adolescence (cf. *Romer* 2010). Thus, while in adults the PFC is comparably more active especially in socio-emotional demanding situations (cf. *Chein* et al. 2011), subcortical regions of the brain, like the VS are sometimes more responsive during puberty. Studies showed that weak EFs are associated with higher risk-taking in adolescents and young adults (e.g. *Magar/Phillips/Hosie* 2008). In 6-year-olds, an association of poor EFs and high incidence rates of unintentional injuries could be shown (cf. *Schwebel* 2004). Furthermore, EFs are associated with more functional pedestrian behavior in 3- to 9-year-olds (cf. *Briem/Bengtsson* 2000). To our knowledge, there is no study yet examining the influence of EF on the risk to suffer a bicycle accident in the age group of 10- to 14-year-olds.

2 The project 'YOLO – self-confident bicycling' aiming to prevent bicycle accidents

YOLO is short for 'You only live once', an expression kids often use when engaging in risk-behavior. However, the expression can be interpreted in another way which is often neglected: One indeed only lives once and that this one life is very precious.

The study consists of two parts. The aim of the first part is to identify factors that set kids that have suffered a bicycle accident apart from kids that have not. In the second part of the study, an intervention program is developed and evaluated with the aim to reduce the identified risk-factors.

2.1 Sample

Students, aged 10 to 14, from different types of secondary schools, will be asked to complete online self-assessment questionnaires. Entire classes of students will be assessed to control for potential confounders. Students of the same class are assumed to be similar concerning socio-economic background and regional conditions, but may differ significantly in bicycle riding behavior and attitudes toward bicycling.

Despite the high number of accidents compared with other age groups, serious bicycle accidents reported by the police or the school are relatively rare. In order to increase reliability of our data, we will recruit participants from randomly selected schools in areas of Germany with a high number of bicycle accidents (cf. *Neumann-Opitz/Bartz/Leipnitz* 2012) and ask for all kinds of bicycle accidents (not only those needing medical attention). The parents will also be asked to fill in a questionnaire for the purpose of validation of the testing instruments (see section 2.2.). The questionnaire will contain questions about their personal background, bicycle use, attitudes towards cycling as well as attributes regarding their child's cycling behavior, bicycle accidents, and EF. Due to the fact that the traffic infrastructure, like existence of bicycle tracks, has an influence on the number of bicycle accidents, there will be also an online-questionnaire for the principals of the participating schools asking for the infrastructure in the vicinity of the school.

2.2 Measures

Socio-demographic data. Due to the fact, that socio-demographic variables like age and sex are known to be significantly correlated with an increased risk of accidents this information will be collected.

Executive Functions. EF will be assessed using the German 'BRIEF-Behavior Rating Inventory of Executive Function' (*Drechsler/Steinhausen* 2013).

Risk-taking. Risk-taking will be assessed with the Novelty-seeking Scale of the 'JTCI - Junior Temperament and Character Inventory' (*Goth/Schmeck* 2009).

Peer influence. Resistance to peer influence is assessed using a German version of the RPI (cf. *Steinberg/Monahan* 2007).

Information about cycling-behavior. A more detailed description of cycling-behavior should help to identify influences of EF and risk taking behavior. Relevant questions in this realm are: How often do you use your bicycle? Do you go to school by bicycle? How fast are you going? How safe are you going? Do you use a helmet?

Information about accidents. Questions about all kinds of accidents (household, leisure and sport) will be asked: frequency, circumstances, the nature and severity of the consequences of the accident.

Knowledge about traffic regulations. A study by *Weishaupt* et al. (2004) showed that students of primary and secondary education in Germany show significant knowledge gaps when it comes to traffic regulations. Knowing the rules is of high importance for acting accordingly, therefore, participants are asked to answer questions to assess their knowledge of traffic rules.

3 Development and evaluation of a prevention program

The aim of the first phase of the study is to identify the variables that put 10- to 14-year-olds at risk to suffer a bicycle accident in the future. Based on the findings, an intervention program will be developed targeting kids that score high on the variables associated with accidents rates.

Compared to former interventions in this area and age group, the present program will contain of a more multimodal approach aiming at an increase of self-efficacy and self-regulatory competence in the domain of bicycling and less teaching of traffic rules. Self-efficacy develops over time and is central for the perceived control over ones actions at designated levels (cf. *Bandura* 1993). Self-efficacy can be enhanced, e.g. via exposition to positive models and experience based teaching of strategies to overcome challenges, like bad peer influence (cf. *Schunk/Meece* 2006). Self-regulation theory also provides a fruitful frame to implement developing aspects of EF in the sequence of daily adaptive behavior (cf. *Hofmann/Schmeichel/Baddeley* 2012). The interventions will contain topics such as puberty, the function of emotions and emotion-regulation, as well as their impact on risky decision making – again, especially in the context of bicycling. Via learning by a positively perceived model (e.g. a "star" out of the bicycle community) and possibility to experience several high and low risk situations in a safe environment (e.g. in a traffic practice area or via computer simulation or virtual reality) the kids will be supported to integrate their own behavior in the frame of self-regulation (cf. *Romer* 2010). This provides the most important concepts of emotion-guided decision making and short- and long-time consequences of behavior, as well as many working points for autonomous and functional problem-solving and impulse-control.

The intervention program will be implemented and evaluated in a pre-post design with an experimental and a no-treatment control group.

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