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An ecological stance on risk and safe behaviors in children: The role of affordances and emergent behaviors



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A B S T R A C T

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Unintentional injuries are a major cause of disability and death among children. Initial strategies to address child safety issues have primarily either focused on the environment, trying to identify “risk environments”, or on the individual, trying to identify “at risk children”. More recently, the interaction between child and environment is starting to be addressed in order to enhance the understanding of childhood injuries. The present review suggests a framing of these studies in ecological theory, which implies that children with certain characteristics perceive certain affordances in the environment. In this context, risk may be considered a relational concept. The literature on risk prevention is reviewed and the role of caregivers in managing affordances is emphasized.

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1. Introduction

Unintentional injuries are a major cause of disabilities among children, with a large impact on their own lives as well as the lives of their families. According to the World Report on Child Injury Prevention (Peden et al., 2008), every day around the world more than 2000 families lose a child due to unintentional injury. The problem of child safety is somewhat complex to deal with for three main reasons. First, the environments that children move in are mostly designed by and for adults with minimal adaptations for children. For instance, inadequate physical constraints that do not consider a child's body dimensions, such as a balcony in which the railings are too low or spaced too far apart (i.e., more than 10 cm), or a window sill that is too low, fail to protect children's falls from heights (Istre et al., 2003). Many safety barriers designed to prevent access to risk environments have poor or inadequate design

(e.g., horizontal bar barriers with footholds) and therefore are easily crossed by children (Cordovil, Barreiros, Vieira, & Neto, 2009; Cordovil, Vieira, & Barreiros, 2011). Second, the action capabilities of children are substantially different from those of adults, which are usually presented as a reference. Children differ physically and cognitively from adults. For instance, preschoolers cannot read, which sometimes might be a problem. Many poisonous products look like and come in similar looking containers to drinks or food (Lueder & Rice, 2008). Those containers might be labeled as a “juice” or a “home cleaner” but for a child that cannot read they are indistinguishable. Pictogram symbols must also be tested if the intention is to warn children. For instance, the skull and crossbones symbol used as a hazard symbol for poisonous substances may be interpreted as “pirate food” (Schneider, 1977). Safe packaging with child-resistant caps and safe storage are particularly important to prevent poisoning. Third, children's behavior is frequently unpredictable and variable, i.e., children find divergent solutions to interact with an environment designed for adults. For instance, adults usually walk up or down the stairs, but children can consider a set of stairs as an object of fun to play with, and they can chose creative

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ways, sometimes other than walking, for going up or down (e.g., see Ulrich, Thelen, & Niles, 1990). Sinnott (1977) vividly described how children behave in the home environment, using their houses in creative ways that sometimes have not been foreseen by the designer: “children will crawl about the floor, climb onto the window ledge, squeeze through stair balustrades, slide down the stair handrail, swing on the gate, run from room to room and ride bikes inside as well as out” (p. 76). These three child safety factors are related to: the environment or the task performed by the child (i.e., inappropriate design); the child (i.e., the specificity of his/her action capabilities); and the relation between the child and the adult (i.e., the unpredictability of the child's behavior for the supervisor). The interaction of these three factors, sometimes results in accidents and injuries.

Most early analyses concerning child safety issues have endorsed views in which either the risk environment or the individual at risk have been the focal point. In order to further prevent accidents and injuries, the aim of the current paper is to underline the need to consider risk in behavioral terms, as a dynamic, relational, emergent and constantly actualized state of affairs between the child and the environment, as proposed by an ecological approach. To this end, in this article, we first review the literature on risk prevention and present the contributions of previous research to the identification of “risk environments” and “at risk children” (i.e., accident prone children). Next, we refer to some studies that have already considered the importance of the interaction between the individual child and the environment when addressing risk issues. We propose that those studies could be understood from an ecological approach to risk, which considers risk as a particular state of the child in relation to the environment. In addition, risk is associated with uncertainty (Aven, Renn, & Rosa, 2011). Children engage in a number of actions that sometimes have different outcomes than expected. A risk situation exists when the outcome is uncertain and the child's safety is at stake. From this viewpoint risk cannot be seen as something inherently negative. To the contrary, we argue that risk behavior and unintentional injury are emergent phenomena whenever there is the potential for a misfit between a child's action capabilities and his or her environment. So rather than understanding risk as something to be prevented, it is the emergence of behavior that might lead to injury, which should be prevented. But that is not to say that we can or should completely regulate risk environments.

Children's actions lead to perceptions of the environment which in turn lead to new actions in the environment. Therefore, we propose that risk is a dynamic concept and, accordingly, children's actions need to be understood as a result of actualization of affordances (Smith & Pepping, 2010). Affordances, the opportunities for action in the child's environment, are intimately tied to the child's action capabilities in that same environment. Greater understanding of the dynamics of individual capabilities and environmental opportunities for action and their relative fit is needed for a better understanding of risk environments and their potential negative behavioral consequence. It is slight (unanticipated) changes in the child's action in a given environment, or changes in the environment itself,

that bring about risk. Therefore, the negative behavioral consequences of risk, injury, is emergent. This ecological approach is postulated to advance the understanding and management of child safety issues. Finally, we emphasize the importance of caregivers in selectively structuring environments for the children they are caring, in order to manage these risk environments and the risk behaviors they invite without impeding children's opportunities for exploring and learning.

2. “Risk environments”

Traditionally, risk has been related to the expected losses that can be caused by an event, in association with the probability of occurrence of this event (*ISO/IEC Guide 50, Safety aspects – guidelines for child safety, 2002*). Accordingly, the analysis of risk environments has been based on statistics of children's injuries in different environments in combination with the clinical impact of such injuries. The World Report on Child Injury Prevention (Peden et al., 2008) identifies five leading causes of children's unintentional injuries around the world: road traffic injuries, drowning, burns, falls, and poisonings. Accident prevention analyses have focused on environments with features like roads (related to traffic injuries), water surfaces (related to drowning), objects or places with high temperatures (related to burns and scalds), places with different height levels (related to falls), and access to toxic substances (related to poisoning). Some environmental characteristics such as family related variables (e.g., socio-economic status), novelty and variation in daily routines, lack of physical constraints, and lapses in supervision are known to increase the possibility of accidents (Neto et al., 2008). Some causes of unintentional injuries have daily and seasonal trends. For instance, falls from heights peak around meal times when supervision might be more careless (Istre et al., 2003) and occur more frequently in the summer months, presumably because around that time of the year windows tend to be open (Bull et al., 2001). In relation to the socio-economic environment, children in low-income and middle-income countries, especially poor children, encounter more unintentional injuries (Delgado et al., 2002; Hyder et al., 2008). Several aspects contribute to the poverty penalty, such as education, habits and routines, family dimension, environment quality, and poor parental supervision routines (Peden et al., 2008; Towner, Dowswell, Errington, Burkes, & Towner, 2005).

The strategy of identifying risk environments is undoubtedly very important, since it allows the delimitation and deeper analysis of places where the probability of accidents with children is higher. However, the analysis of “risk environments” should not be separated from the analysis of how individuals act in those environments. As we argue, “risk” is not a property of a specific environment, but it emerges from the interaction between a specific individual and a specific environmental condition.

3. “At risk children”

The concern for the safety of young children has led to a growing amount of research related to individual

constraints that identify some children to be more prone to risk than others. Variables such as age, gender, socioeconomic factors, and temperament have been examined as possible causal factors associated with children engaging in unsafe behaviors (Peden et al., 2008). Research has shown that injuries are age specific. For instance, children aged 0–4 year shows the highest rate of drowning, whilst traffic injuries are the leading cause of death among 15–19-year-olds (Peden et al., 2008).

Boys tend to have more severe and more frequent injuries than girls (Crawley, 1996; Moorin & Hendrie, 2008; Peden et al., 2008). Characteristics related to a child's temperament, such as the activity profile, impulsivity and distractibility, have also been related to accidental injuries (e.g., Manheimer & Mellinger, 1967; Pless, Taylor, & Arsenaault, 1995). Plumert and Schwebel (1997) showed that eight-year-olds with high levels of gross motor activity, intense excitement for pleasurable activities, enjoyment of high intensity situations, and fast speed of response initiation had an increase of severe day-to-day injuries. In the same study, overestimation of ability and not temperament was related to accidental injuries in six-year-old boys. The focus on the identification of the “at risk children” has led to the development of questionnaires to evaluate attitudes and behaviors towards risk situations (e.g., Morrongiello et al., 2010; Morrongiello & Lasenby, 2006). For caregivers' to adjust supervision in order to prevent child injuries it is important to identify “at risk children”. However, the probability of the “at risk children” actually being at risk depends on their interaction with the environment.

Whilst the importance of data gathered by epidemiological approaches is undeniable, Peterson, Farmer, and Mori (1987) have long proposed that it should be complemented by different approaches, such as process analysis, “which examines injury as a series of person by environment interactions rather than as a discrete event” (Peterson et al., 1987, p. 34). Morrongiello and Schwebel (2008, pp. 81–82), highlighted that “The lack of longitudinal research designs and inattention to interactive processes leading to injury have left scientists with a poor understanding of whether and how risk factors change with development”. Some empirical studies have tried to fill this gap by studying the short-term/acute interactions between child and environment in different situations and at different stages of lifespan (Adolph, 1995; Cordovil, Santos, & Barreiros, 2012; Cordovil et al., 2011; Morrongiello, Walpole, & Lasenby, 2007; Plumert, 1995; Plumert, Kearney, Cremer, Recker, & Strutt, 2011). However, longitudinal studies are scarce (Adolph, 1997; Schwebel & Plumert, 1999). Although some of this work is based on an ecological approach to child safety, we here suggest that these studies should be framed in an ecological approach to risk as explained in the next section.

4. An ecological approach to risk: affordances and emergent behaviors

For Gibson (1979, p. 127) to perceive an affordance is to perceive how one can act when confronted with a particular set of environmental conditions. In visually guided locomotion some features specify dangerous situations. As

Gibson (1979) pointed out “A brink, the edge of a cliff is a very significant terrain feature ... the closer to the brink the greater the danger” (p. 37). Gibson further explains that some features might simultaneously provide positive and negative affordances. For example, a fire affords warmth but it also affords injury to the skin if one gets too close; as Gibson (1979) mentioned “There is a gradient of danger and a limit at which warmth becomes injury” (p. 39). Following this ecological approach, we propose that affordances inform about a “gradient of danger” that might lead to injury. According to this view, affordances are action-relevant properties of the environment taken in reference to the actor's action capabilities, but that exist independently of his or her needs or intentions. It was also suggested that affordances can also invite behavior (see Withagen, de Poel, Araújo, & Pepping, 2012), that is, they may attract a certain behavior, but only if the agent perceives that affordance. The invitation to a specific behavior demands the presence of an observer. Framing the concept of affordances in the context of goal-directed action, and considering that affordances can invite behaviors, may lead to a further understanding of child safety issues.

When unintended injury occurs, the action performed by the child had a different outcome than was expected. The unintended outcome might derive from an unanticipated actualization of affordances; the fit between the child's action possibilities and its environment, or from the natural or developmental limits of the perceptual-motor system of the individual. Children often push the boundaries of their physical limitations and frequently misperceive the dangers and consequences of their actions (Adolph, 1997).

Affordances can lead to safe outcomes if they are accurately perceived, or to negative outcomes if the information specifying them is not picked up. However, the perception of affordances is not independent of the perceiver's actions, since perception and action are tightly coupled. In Gibson's (1979) words “we must perceive in order to move, but we must also move in order to perceive” (p. 223). Errors in judging the relation between one's physical abilities and the demands of the situation have been suggested as an important factor contributing to accident risk (Plumert, 1995). Negative outcomes might occur if a child does not perceive that a playground equipment is too high to jump from, or if a child falls down a set of stairs because of a distraction, speed, poor visibility, or misleading perceptions of the ground surface.

The inaccurate perception of affordances may result from a difficulty in actualizing the fit between the action capabilities of the individual and the opportunities arising in the environment. Action is the fundamental basis for such actualization, particularly in periods of growth spurt and in the neighborhood of new skills acquisition. It is expected that children with less opportunities for practice and perceptual attunement, especially in critical moments of development, may experience a higher probability of unintentional injury. Alternatively, very active children are prone to suffer “calculated risk” injuries, while they are involved in the intentional exploration of contextual and body constraints. To date, the relation between injury and motor ability has presented inconsistent findings in the

literature (see [Schwebel, Binder, Sales, & Plumert, 2003](#)), but it seems reasonable to approach accident analysis from this point of view. We argue that in terms of injury prevention strategies, it is possible to help individuals to accurately perceive “risk affordances”, those that have the potential to lead to unintentional injury. Both environmental and behavioral modifications might be used for this purpose.

The matching of an individual's characteristics with what the environment offers, defines what risk or safe behaviors may be. Importantly, affordances may arise and dissolve over time. In some situations, the actions of the child might create new affordances even though the surfaces and objects in the environment remain the same. Consider a child who approaches a swimming pool getting close enough to jump in the water, a behavior that would not be possible from a more distant location. In other cases, affordances are created by changes that occur in the child's environment, for instance, when a child stands on the sidewalk waiting for a gap in traffic that is big enough to cross the street. Finally, both the child's actions and the changes in the environment might create new affordances, for instance, when a child cycles through a crowded city. Indeed, action capabilities as well as environmental possibilities for action evolve and dissolve over shorter and longer time scales. As children grow, action capabilities change, sometimes very smoothly, and sometimes very rapidly. Therefore, what is risk behavior at a certain moment, and for a certain child, may not be at another moment.

In most research on affordances the focus has remained on the perception of affordances and action boundaries of a single specific action and whether children are able to perceive if that action is possible or impossible (e.g., [Kretch & Adolph, 2013b](#); [Plumert, 1995](#); [Plumert & Schwebel, 1997](#); for a review see [Adolph & Berger, 2006](#)). Recent research using virtual reality settings has started to investigate streams of affordances in dynamic environments, using an immersive interactive bicycling simulator to study how children perceive and act on gap affordances (e.g., [Chihak, Grechkin, Kearney, Cremer, & Plumert, 2014](#); for a review see [Plumert & Kearney, 2014](#)). The problem of navigating through traffic environments is challenging for children, since up to 11 years of age they exhibit poor skills in recognizing dangerous places to cross the road ([Ampofo-Boateng & Thomson, 1991](#)). However, the study of this issue in real settings is difficult because it puts children at risk for injury. So, the studies in virtual reality scenarios provide a good example of how to bridge research on children's perception and action with the problem safety on road environments, and have advanced some knowledge about the differences between children and adults when bicycling across gaps in traffic. For instance, [Plumert, Kearney, and Cremer \(2004\)](#) showed that 10- and 12-year-old children chose the same size temporal gaps as adults to bicycle across a single virtual roadway. However, when compared to adults, children get started later and leave less time to spare between themselves and the approaching vehicle, being also “hit” more often when trying to cross tight gaps in high-density traffic. Further research ([Grechkin, Chihak, Cremer, Kearney, & Plumert, 2013](#)) suggests that, when

crossing two lanes of opposing traffic, 14-year-olds adjust their gap choices to their action capabilities, but 12-year-olds do not. These studies highlight not only that children and adults have different action capabilities but also that younger children do not match their behavior to their action capabilities. The effects of training with the aim of improving the attunement between perception and action in these settings were still not investigated, but constitute an important challenge for the future.

The investigation of streams of affordances in dynamic environments is undoubtedly important. However, in many situations children have multiple options and solutions to reach their goal (other than a dichotomous choice such as to pass a gap now or to pass later). That is, multiple actions are afforded concurrently. For instance to reach a cookie jar in a kitchen cabinet, a child might chose to stand on chair, climb up onto the counter, get a piggyback ride from a friend, or find some other creative way to reach it. The results of recent studies on affordances in the physical activity and sports-domain have shown that often people are faced with situations where multiple actions are afforded simultaneously ([Barsingerhorn, Zaal, De Poel, & Pepping, 2013](#); [Hristovski, Davids, Araujo, & Button, 2006](#); [Pepping, Heijmerikx, & de Poel, 2011](#); [Pinder, Davids, Renshaw, & Araújo, 2011](#)). To address how people deal with the situations where multiple actions are afforded [Cisek \(2007\)](#) proposed an important hypothesis to consider in an ecological approach to injury prevention. Traditional psychological theories assume that selection (decision making) occurs before specification (movement planning). Drawing on ideas from neuroscience and ecological psychology, Cisek argued that during overt performance of movements the processes of action selection, the process of choosing an action from among many possible alternatives, and action specification, the process of specifying the spatiotemporal aspects of possible actions, operate simultaneously and continuously. Similar to what is proposed by the theory of affordances, it is argued that action specification and selection should be regarded as one and the same dynamic process (see also [Smith & Pepping, 2010](#); [Smith, Zaal, & Pepping, 2012](#)). For instance, in the context of child safety, the decision to skip, walk or run when crossing a busy road is part of the spatiotemporal demands that specify safe crossing. Behavior, then, can be seen as a constant competition between affordances (see also [Cisek & Kalaska, 2010](#)). From this viewpoint, performance accuracy may suffer when multiple actions are afforded concurrently, with injury being an important potential negative behavioral consequence.

[Newell \(1986\)](#) described how movement arises from the interaction between three types of constraints: individual (personal characteristics), environmental (social and physical characteristics of the environment), and task (goals, rules or conditions, and implements or tools used for performing the task). Changes in any of these constraints will affect affordances and the resultant actions. Hence, child behavior is a result of constant competition between affordances, in the context of rapidly changing constraints during infancy and childhood.

We argue that changes in individual characteristics induce a different relationship with the environment

properties, meaning that the fit between individual and environment changes with growth. The relationship between body and environment is not easily perceived by children during early development. Until the second year of life, toddlers frequently make body self-awareness errors related to their body size (e.g., trying to squeeze their bodies through doors that are too narrow or to fit in replica toys that are too small for them), or related to the capability of perceiving their body as an obstacle (e.g., trying to push a stroller attached to a blanket where there are standing without realizing that they have to remove themselves from the blanket) (Brownell, Zerwas, & Ramani, 2007). These self-awareness or self-perception errors sometimes might lead to injury. The fact that infancy and childhood are defined precisely by a fast rate of change of the individual's characteristics poses an additional challenge. These changes occur rapidly in the first years of life, causing the rates of types of injuries to change dramatically even over three-month time periods (Agran et al., 2003). There is some support for the hypothesis that the probability of accidents increases in periods of fast body changes or in early stages of motor acquisitions. For example, Adolph and Avolio (2000) examined whether toddlers could adapt to changes in their body dimensions and variations in the terrain by loading them with different weights and observing how they navigated safe and dangerous slopes. Toddlers could adapt to experimental manipulation of their body dimensions, but the adjustment was neither immediate nor perfect. The infants' errors were more frequent when they were loaded, probably because their exploratory activity diminished in this condition. The modification of a physical constraint (i.e., body weight) caused a change in the infant's motor behavior. During infancy and childhood, children's height and weight change considerably and growth itself seems to be an important cause for the variability and unpredictability of children's behavior. As development progresses, children's skills and competences change sometimes quite rapidly. This change might cause children to respond with non-adaptive actions even to situations with which they could safely deal previously, in part this might be a problem of perceptual attunement as explained in the next section.

5. Perceiving affordances that lead to risk behaviors

Research indicates that children perceive affordances from very early stages of development (see Ulrich et al., 1990, for a review). Since perceptual systems are not yet mature at birth, biological maturation and experience further refine perceptual competence. There is ample evidence for the suggestion that experience is important in perceiving affordances (Adolph, Eppler, & Gibson, 1993; Klevberg & Anderson, 2002; Ulrich et al., 1990; Zwart, Ledebt, Fong, de Vries, & Savelsbergh, 2005). Perceptual attunement refers to perceptual changes over a period of practice with the informational variables upon which actors rely (Fajen, Riley, & Turvey, 2009; Jacobs & Michaels, 2006).

Eleanor Gibson (1969) argued that with experience, people learn the strategy that is most economical for the task at hand and thereby focus on the minimal number of

invariants that will successfully discriminate among the events of interest. Differences between children at different skill levels may reflect (at least, in part) differences in perceptual attunement. There is a growing body of research concerning the process of attunement in adult learning (e.g., Jacobs & Michaels, 2006; Wagman, Shockley, Riley, & Turvey, 2001) but studies of attunement during development are less common (van Hof, van der Kamp, & Savelsbergh, 2006, 2008). In the injury prevention literature those studies are mostly on pedestrian safety and they have not been framed within the context of ecological theory (e.g., Thomson et al., 2005; Whitebread & Neilson, 2000). Skilled perception of affordances in risk environments evolves with practice, and cumulative experience under different environmental and task constraints seems to be a good way of learning.

The role of experience in the perception of relevant environmental information is illustrated by some studies using the visual cliff task (Bertenthal & Campos, 1987; Bertenthal, Campos, & Kermoian, 1994; Campos, Bertenthal, & Kermoian, 1992). As famously first developed by Eleanor Gibson and Walk (1960), this task consisted of a simple experimental setup that gives infants the illusion of approaching a drop-off. The cliff consists in two identically patterned horizontal surfaces, one well below the other; the upper is extended over the lower by means of a sheet of transparent glass. This apparatus was initially used by Gibson and Walk to investigate depth perception (Gibson & Walk, 1960) since it created the visual illusion of a cliff, while protecting the subject from injury. Studies with this task (e.g., Bertenthal & Campos, 1987; Bertenthal et al., 1994; Campos et al., 1992) suggest that self-locomotor experience is a strong predictor of avoidance behavior in the visual cliff. For example, Campos et al. (1992) tested crawling and pre-crawling infants on the visual cliff, finding that, if age was held constant, only crawling infants showed significant cardiac acceleration when lowered onto the deep side. On the other hand, "artificial" experience provided by locomoting in a walker also generated cardiac acceleration, interpreted by the authors as evidence of wariness of heights. Other studies (Adolph, 2000; Kretch & Adolph, 2013a) suggest that there is not a generalized wariness of heights because learning to perceive affordances in the course of development seems to be task specific. For instance, nine-months old babies were shown to avoid reaching over impossibly wide gaps if tested in an experienced sitting posture, but the same babies fell into those gaps while attempting to reach in a less familiar crawling posture (Adolph, 2000). Locomotor experience in each specific posture seems to be necessary to become attuned to the information that specifies the affordances in different environments. These studies indicate that children perceive what the environment offers, and suggest that the perception of danger comes from active exploration of the world.

Some studies with older children (Schwebel, 2004; Schwebel, Lucas, & Pearson, 2009) have tried to diminish children's overestimation tendency in dangerous situations either by imposing a period of forced latency before children's decisions in dangerous situations or by introducing visually salient stimuli in dangerous scenarios. Despite the

longer decision latencies in both situations, children's accuracy did not improve in any of the scenarios. These results seem to indicate that experience with acting in a given task, rather than time to organize behavior, might be necessary for children to become attuned to the relevant information in that task. Several studies in the field of pedestrian safety have found that repeated practice can improve safe street-crossing behaviors in children (e.g., Ampofo-Boateng et al., 1993; Young & Lee, 1987).

The type of information that children become attuned to while exploring the world is influenced by experience and education. Parents have an important role in ensuring safety of their children while providing appropriate challenges, but the levels of parental supervision differ according to the vicissitudes of individual parents and even according to the gender of the parent. Mothers tend to adopt more safety-oriented parenting choices whereas fathers tend to emphasize challenge (Ishak, Tamis-LeMonda, & Adolph, 2007). The gender of the child also influences parental supervision. In fact, the differences in risk-taking behaviors between boys and girls, that are usually considered to result from a purely individual constraint (i.e., gender), might well result from socialization practices. Parents demand more independence in their sons and more caution in their daughters, perceiving risk-taking behaviors to be more acceptable for boys than for girls (Morrongiello & Dawber, 1998, 2000). This parental behavior is likely to promote differences in the kind of environmental information the children become attuned to.

In some situations to be attuned to relevant information specifying affordances might be particularly difficult. For instance, walkers rely on shine to predict slippery ground even though shine is not always a reliable visual cue for friction (Joh, Adolph, Campbell, & Eppler, 2006). Temperature is also a difficult variable to become attuned to. Objects and places with high temperatures might lead to burns and scalds. However, temperature is not visually nor acoustically available – it is a particular, and momentary, energetic state of objects. To gather information about an objects' temperature one must touch, or alternatively, learn about their effects on the body when touched. The temperature of an object may also be derived from a conjunction of conditions. For instance, a pot over a stove can be hot, but it doesn't have to be, specifying a range of affordances. A blue-and-yellow light under the pot increases the chances of the pot being hot and further specifies the affordances of the pot. It is the combination of conditions that specifies affordances for grasping or touching actions. The same problem exists in electrical hazards.

Inefficient or dangerous behaviors usually occur when people, especially children, need to operate close to their action boundaries. When standing on a high wall the affordance for jumping off can have a gradient of danger that is dependent upon the action capabilities of the child and the height of the wall. When the wall is low enough relative to the action capabilities of the child, jumping is clearly afforded. There is a boundary zone of wall heights relative to action capabilities in which there is an increased uncertainty about whether or not jumping is afforded. This boundary area is usually the most unsafe one. As suggested

by Plumert (1995), “when children are confronted with situations that are beyond their ability, accident risk should peak in the range just beyond their ability and decline steadily thereafter” (p. 867). We argue that experience furnishes a major contribution to perceptually attune children to fine-grained information that clarify previously ambiguous transition boundaries from a possible and safe to an impossible and unsafe behavior.

6. Shaping the world: affordances and behavior in risk environments

Prevention of childhood injuries has led to a debate concerning the relative merit of environmental versus behavioral strategies. Researchers have tried to devise ways to decrease the necessity for supervision by pursuing different kinds of interventions to reduce environmental hazards (e.g., stair safety barriers, swimming pool fences, safety plugs or bicycle helmets). However, environmental modifications sometimes lead to ironic effects, i.e., increased risk taking behavior in adaptation to environmental modifications intended to reduce risk taking behaviors. This behavior has been demonstrated in children (e.g., Morrongiello, et al., 2007) and in parents, who allow children to engage in greater risk taking behavior when wearing safety gear or when environmental modifications reduce risk perception (Morrongiello & Major, 2002). As Morrongiello (2005) pointed out, not all environments can be modified to reduce the possibility of injury, and not all behaviors are easily amenable to modification. Hence, both kinds of strategies should be viewed as complementary to the prevention of childhood injuries.

Despite a necessity for complementarity, the developmental stage of the child must be taken into account when selecting injury prevention strategies. During early development parents ordinarily use physical interventions that remove children from hazards or hazards from children in order to prevent injury. As children grow older though, parents increase their reliance on verbal communication (Gralinski & Kopp, 1993). The use of verbal warnings in risk scenarios is more complex and diverse for older than for younger children, taking into account the child's development and communicative abilities (Tamis-LeMonda, Adolph, Dimitropoulou, & Zack, 2007).

As children grow, adults must be able to shape the environments, creating the ecologies in which children act. Therefore, they must be able to perceive affordances for children with good accuracy. There are some indications that adults can be quite accurate in perceiving the affordances of other adults (e.g., Fischer, 2003; Mark, 2007; Ramenzoni, Riley, Shockley, & Davis, 2008; Rochat, 1995; Stoffregen, Gorday, Sheng, & Flynn, 1999; Stoffregen, Yang-Yi, & Gorday, 1995). Some studies (Cordovil, Andrade, & Barreiros, 2013; Cordovil & Barreiros, 2010, 2011; Cordovil et al., 2012; Ishak et al., 2007; Schwebel & Bounds, 2003) have approached the evaluation of a child's action limits by an adult, a very common and relevant situation for the perception of affordances. The results of these studies indicate that adults can be quite accurate in perceiving children's affordances, but some characteristics of the task, of the child or of the observer might influence

that level of accuracy. There are also indications that parents tend to overestimate children's ability less frequently than children themselves and that children judge their physical abilities more cautiously when parents are present (Schwebel & Bounds, 2003). In some situations, children and adults act jointly in the environment. For instance, parents help their children to cross the street. In such cases, the affordances for the adult-child dyad are usually different from those of either the child or the adult. Importantly, adults are able to perceive the dyad's affordances when interacting with a child (Chang, Wade, & Stoffregen, 2009). On the other hand, children might also adjust their behavior when interacting with adults. Using the pretend road method (i.e., pretend crosswalk set adjacent to a real road where children are instructed to use traffic on the real road to decide when to cross), Barton and Schwebel (2007) found that there was an increase in risk-taking when children were fully supervised, a finding that was attributed to the fact that parents and not children decided when to cross the road. Conversely, children behaved more cautiously when supervised but crossing without a parent. These results highlight the importance of giving children progressive levels of autonomy as they learn to move about in different environments.

The environments children move in are selectively structured for them by adults. They are characterized by the presence of caregivers, by the existence of objects, places and events selected for children (toys, equipment and surfaces) or selected to be kept away from children (guns), and by the promotion of play. Reed (1996) argued that these are the conditions for the field of promoted action, which is characterized precisely by the presence of affordances for children as perceived by adults; the exclusion of negative affordances for children as perceived by other people, and the inclusion of support for actions of children in different timings. Importantly, the activity of children starts before they have the autonomy to realize affordances to which the task is directed. Children do things before they know how to do them (Reed, 1996). This may be the indicator for caregivers to start helping them to develop a certain skill. Children act towards objects or surfaces, while learning how to act with those objects, or on those surfaces. That is why children place themselves in a position of encouraging adults to help them in promoting their action.

Caregivers in all cultures promote the acquisition of competence in everyday skills. This is done by organizing the places of the environment and the daily routines of children in ways that promote a gradual process of awareness and accomplishment. The role of caregivers in constraining risk experiences, by supervising children's behaviors and by structuring the environment, is specific to each child developmental stage. Infants are continuously exploring the world. As van Hof pointed out "Exploration is an ongoing coupling between actions and perception by which infants learn to perceive what actions are appropriate in a particular situation" (van Hof, 2005, p. 9). As the child's action capabilities develop, the amount of opportunities for exploration increases and new affordances are created. A reduction of experiences acts the inverse direction. Probably, younger infants will not perceive affordances as accurately as older children, and they have more

chances to choose potentially dangerous behaviors. In the categories of accidents that we have previously described, a higher prevalence of registered events was found in those developmental stages. This is probably due to a combination of children's level of maturation and inexperience, which might interact with numerous other potential factors of the child or of the task.

In summary, during the process of discovering what the world has to offer the child sometimes engages in dangerous behavior. In terms of child safety it would be important to determine not only how the child perceives affordances in risk settings, but also how the adult perceives such affordances for that child, since in the early years the environments the child moves in are controlled and managed by adults. A better understanding of child's interaction with different environments and of the accuracy of adults' perception of affordances for children, will help parents or caregivers to know what constraints should be dealt with in different situations, so that the children's active exploration of the world can go on in a safe environment.

We would like to emphasize that a safe environment is not the same as a danger free situation. Not only because a danger free environment is difficult to achieve, but also because we believe there are positive developmental outcomes associated with acting on affordances that have a certain gradient of risk. As Plumert (1995) highlighted, we face a developmental dilemma, since "by its very nature, development involves aspiring to do things that are beyond one's current level of ability. Without such motivation, it seems unlikely that development would move forward." (p. 875). As explained, due to the emergent nature of behavior in relation to affordances, when affordances come into and go out of existence, there are regions of afforded action that can be seen to contain more inherent risk. The overwhelming emphasis on injury prevention in the current literature has neglected the positive aspects of risk. However, some studies (Brussoni & Olsen, 2011, 2013) indicate that parents perceive the value of risk experiences, seeking to strike a balance between providing their children with opportunities for risk exposure and protecting them from serious injury. Exploration, challenges and the experience of acting in risk environments have an important role on children's development since they provide valuable opportunities for learning, problem-solving and developing social competence.

7. Concluding remarks

In this paper, an ecological approach to risk was advanced, highlighting the importance of analyzing the interaction between the child and the environment when addressing risk issues during child development. We argued that risk affordances are emergent whenever there might be a potential misfit between the child's action capabilities and his or her environment.

On the other hand, affordances can lead to safe outcomes when accurately perceived, so injury prevention strategies must focus on facilitating the actor's perceptual attunement to the relevant variables in the environment (e.g., marking a stripe on the nosing of each tread in

stairways, teaching children to see the relevant information before crossing the road or bicycling across traffic-filled intersections). The use of computer-simulated environments and immersive, interactive virtual environments seem to be promising safe strategies to enhance children's perceptual learning of affordances in risk environments (Thomson et al., 2005). However, technology is not a fundamental condition to gain suitable exposure to risk during development since adults can help children to perceive risk affordances in real life situations.

Despite the emergent nature of risk, constant surveillance of children is neither possible nor desirable. The level of autonomy given to children when faced with risk affordances must be progressive and children should be encouraged to make their own decisions even under parental supervision. As Greenfield said: "In today's society there appears to be an aversion to risk; yet, without risk-taking we do not reach our potential" (Greenfield, 2004, p. 1). As a matter of fact, parental and societal apprehension concerning child safety is resulting in an increasingly overprotective style of parenting and aversion to all degrees of danger. Possible dangers are exaggerated and safety and caution are strongly promoted. This attitude might result in the avoidance of many worthwhile affordances that have a gradient of risk and that contribute to a child's development. On the other hand, the removal of all potential hazards may inadvertently lead to inappropriate risk-taking, since children are born explorers of action-boundaries and as such will seek challenging and stimulating experiences (Little, 2006). Moreover, children will not learn to be attuned to affordances in risk environments.

In conclusion, we reviewed the literature on risk prevention and observed that there is a focus on either risk environments or "at risk" – accident-prone – children. To address shortcomings in these approaches to risk prevention an ecological approach was presented in which the interaction between the individual child and the environment is central. This approach considers risk as a particular state of the child in relation to the environment, and child behavior should be seen as a result of constant competition between affordances, in the context of rapidly changing constraints during infancy and childhood. We have proposed that risk cannot be seen as something inherently negative. To the contrary, it was argued that risk behavior and injury emerge from the potential for a misfit between a child's action capabilities and his or her environment. Hence, rather than viewing risk as a thing to be prevented, it is the potentially negative behavior associated with risk, injury, which should be prevented. As Eleanor Gibson (2003) remarked, following Stevenson's words, "The world is so full of a number of things" and children are so curious about them all that it is the duty of caregivers to help them in the discovery process to become attuned to the affordances that are worthwhile to select.

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