Factors that affect primary-school children's sustainable behavior in a resource dilemma

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Abstract

Acting ecologically sustainably and not exhausting natural resources is becoming more and more important. Sustainable behavior can be investigated within the conceptual frame of resource dilemmas, in which users share a common, slowly regenerating resource. A conflict emerges between maximizing one’s own profit and maintaining the resource for all users. While many studies have investigated adults’ behavior in resource dilemmas, barely anything is known about how children deal with such situations and which factors affect their behavior. Due to their still developing cognitive and social skills as well as their self-control, they might act differently than adults. In the present study, 114 children aged between 6 and 11 years played a fishing conflict game. We manipulated (1) whether they played alone or in groups, (2) whether withdrawal was limited or not, and (3) whether they were allowed to communicate within the groups or not. In addition, children’s individual characteristics were assessed that were expected to be related to their sustainable behavior (i.e., delay of gratification, fairness concept, relatedness to nature, math grade, age). Children’s success in maintaining the resource strongly depended on the game context: Similar as for adults, children acted more ecologically sustainably when they played alone, when the withdrawal was limited, and when communication was allowed. In addition, older children acted more sustainably than younger children. The results are discussed in the light of findings with adults and with regard to potential interventions that aim at enhancing children’s sustainable behavior.

Key words: Environmental psychology; Sustainable behavior; Resource dilemmas; Children; Individual differences

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Long-running developments such as global warming, the extinction of species or the overfishing of the seas threaten the existence of this world as we know it and the basis of life of many people. Sustainability, on the other hand, is based on a complex interplay between ecological, social, and economic factors that are not easy to control. Internationally agreeing on common goals for saving this world is only one approach (United Nations, 2015). However, individual behavior is another key point in this interplay. Accordingly, the question of whether and to which degree adults act sustainably and with which individual variables this behavior is associated has been examined in many studies (for reviews and summaries, see Bamberg & Möser, 2007; Gifford, 2014; Kopelman, Weber, & Messick, 2002). But it is at least as instructive to investigate how environment-protecting attitudes and sustainable behavior develop in children and how they could be influenced. Thus, to understand how children deal with slowly regenerating environmental resources and how they act in situations in which such resources are used by several individuals is important because the children of today will be responsible for this planet in the future.

Factors that might limit children's environment-related attitudes and behavior

Children's attitudes and behavior with regard to the environment may differ from that of adults for several development-based reasons (see Gifford & Nilsson, 2014, for an overview of individual variables that influence pro-environmental concern and behavior of adults). First of all, *cognitive abilities* that are still developing in childhood are required to perceive, process, and comprehend the complex relations between different environmental factors (e.g., Boyes & Stanisstreet, 1997; Gathercole, Pickering, Ambridge, & Wearing, 2004; Gifford, 1982; Strommen, 1995). For instance, children's ability to *integrate multiple pieces of information* into judgements or decisions is limited (e.g., Ebersbach, 2009; Wilkening, 1979, 1981). This is reflected, for instance, by the fact that children – compared to adolescents

– consider fewer factors when deciding how a resource should be distributed fairly between several people (Kienbaum & Wilkening, 2009). Another important cognitive aspect is *working memory*. Children's ability to activate information in their long-term memory and to focus their attention on this information in order to process different aspects of this information is still limited (see, for instance, Cowan, 2014, for a review). In addition, children also possess only restricted *prior knowledge* relevant for understanding and acquiring new environment-related information (e.g., Chi, 1978 for the role of prior knowledge on memory) and have often developed certain misconceptions (e.g., concerning the differentiation between "alive" and "not alive"; for an overview, see Gelman & Opfer, 2002). These cognitive factors suggest that children may not comprehend – and thereby rationally evaluate – the complex modes of action underlying environmental problems and the different outcomes of their decisions.

Another aspect of acting sustainably is taking into account not only one's own profit but also the behavior of others who use the same natural resources as oneself. Accordingly, an advanced *Theory of Mind* in terms of being able to understand others' intentions and behavior is required to identify whether another person acts selfishly or is interested in the well-being of the community including the resource. Moreover, it is not only necessary to possess this knowledge but also to base one's own decisions on this knowledge (e.g., Gummerum, Hanoch, & Keller, 2008). Typically, the large majority of 6- to 11-year-old children is able to take the perspective of others (e.g., Wimmer & Perner, 1983). However, research involving social dilemmas, in which one's own goal is in conflict with the goal of other group members, revealed that children are – in contrast to teens and adults – still more focused on the outcome of a co-player's actions than on his or her intention. This leads, for instance, to more frequent rejections of "unfair" (i.e., unequal) offers made by others in distributive games (e.g., the dictator game) – even if the others had no alternative (e.g., Sutter, 2007).

Furthermore, the *conception of distributive justice* (or fairness) is central for sustainable behavior as it includes the fair use of slowly (or not) regenerating resources. While children are able to take, for instance, others' needs and performance into account in decisions concerning the distribution of resources, they are still more guided by the equality principle (i.e., everyone should get the same) or the ordinal principle (i.e., those who invested more into a common resource should also get "more", but in an unspecific way), while adolescents are more strongly guided by the equity principle (i.e., people should be given the very proportion of a resource that corresponds to their investment – not just "more" or "less" like in the ordinal principle; Hook & Cook, 1979; Keller & Canz, 2007; Zinser, Starnes, & Wild, 1991), which requires the ability to calculate proportions.

Related to the conception of fairness is children's *moral development*. Interestingly, the level of moral reasoning did not affect the individual decisions of third to eleventh graders on how to distribute a resource, but when playing in groups and discussing the decisions, group members with more advanced moral reasoning had more impact on the group decisions in terms of stronger social influence (e.g., Gummerum, Keller, Takezawa, & Mata, 2008; Takezawa, Gummerum, & Keller, 2006).

Pro-environmental behavior also often involves conflictual decisions, as doing the right thing might be costly for the individual (e.g., paying more for organic food). Even though preschoolers already know what is right and wrong in many cases and differentiate between "good" and "bad" characters, they face particular difficulties in *transforming this knowledge into behavior* if there are additional costs for "doing right" (e.g., Tasimi, Johnson, & Wynn, 2017). Relatedly, children's *behavioral self-regulation*, required for restraining their own immediate needs in order to generate long-term benefits for the community, is still evolving (e.g., Houser, Montinari, & Piovesan, 2012; Kochanska, Murray, & Coy, 1997). This is in line with the finding that children – compared to adolescents – prefer immediate but small rewards to delayed but larger rewards (Scheres, Tontsch, Thoeny, & Sumiya, 2014).

This suggests that children act more impulsively, which might cause negative environment-related decisions.

To sum up, children might show a poorer environment-related behavior because their cognitive and social skills and their self-control are still developing. Some of these factors are assessed in the present study.

Findings concerning children's environment-related attitudes and behavior

Although many studies have been concerned with the evaluation of programs involving environmental education in childhood (for a review, see Ardoin, Bowers, Wyman Roth, & Holthuis, 2018), not much research has yet examined the elemental development of ecologically sustainable attitudes and behavior in children (see Evans, Brauchle, Haq, Stecker, Wong, & Shapiro, 2007; Myers, 2012). The few existing studies also vary widely with regard to their methods and are thus hardly comparable (Boeve-De Pauw & Van Petegem, 2012). In particular, the question of how children deal with slowly regenerating common resources has rarely been examined. This is remarkable, as even preschoolers are aware of certain environment-related issues, such as the effects of environmental change on nature (Cohen & Horm-Wingert, 1993; Hicks & Holden, 2007; Palmer & Suggate, 2004; Strommen, 1995), and of the negative impact of humans on nature (Boeve-De Pauw & Van Petegem, 2012). The present study aims at providing new insights into how 6- to 11-year-old children deal with a slowly regenerating common resource (i.e., fish) and at uncovering potential factors that affect their behavior.

Studies that have investigated young people's environmental knowledge, attitudes, and behavior so far examined mainly secondary school students (for an overview, see Rickinson, 2010) but rarely any younger children (see Davis, 2009). This is a clear shortcoming, given that children represent the next generation, whose knowledge, attitudes, and behavior are still better malleable compared to older people. Rickinson (2010) suggested that young people's factual knowledge and their understanding of environmental issues is rather poor in general, but may vary as a result of several factors, such as age. In fact, a trend towards a better understanding of and more involvement with environmental issues with age was reported on the one hand (e.g., Chan, 1996; Myers, Boyes, & Stanisstreet, 1999; Palmer, 1995). Older students were also better able to consider long-term effects of environment-damaging behavior (Batterham, Stanisstreet, & Boyes, 1996; Palmer, Suggate, & Matthews, 1996). On the other hand, several misconceptions concerning causal relationships in environmental issues remained stable across different age groups or even increased with age (Boyes, & Stanisstreet, 1993, 1996; Palmer et al., 1996). For instance, even many 11- to 16-year-olds hold over-generalized models concerning the impact of vehicle emission on the environment and do not appreciate that certain technical solutions (e.g., filters) and the behavior of car owners (e.g., style of driving) may contribute to reducing the pollution generated by cars (Lesson, Stanisstreet, & Boyes, 1997).

Assessment of ecologically sustainable behavior

Ecologically sustainable behavior can be assessed in the field or in the laboratory. One approach often used in controlled laboratory studies are resource dilemmas. In resource dilemmas, a group of people shares a common, finite resource that is slowly regenerating with time (e.g., a pasturage or a fishing pond). The conflict emerges between the individual interest to maximize one's own gains and the group's interest to keep the resource alive. The individually rational behavior to strive for the greatest profit leads to irrational outcomes for the collective (Ostrom, 1990). Another important aspect of resource dilemmas is the fact that the consequences of one`s own behavior ensue with a delay. Thus, an apparently optimal strategy for the moment might be a problematic strategy in the long run (i.e., *time trap*; Hendrickx, Poortinga & van der Kooij, 2001; Kortenkamp & Moore, 2006; Messick & McClelland, 1983). Furthermore, trying to maximize one's own profit may harm the whole group (i.e., *social trap*; Messick & McClelland, 1983; Platt, 1973). Hardin (1968) addressed the conflicts related to the use of common resources in his seminal paper, denoting them as the *tragedy of the commons*.

Resource dilemmas are well suited to investigate people's ecologically sustainable behavior (Edney & Harper, 1978; Ernst, 1994) and several factors have been identified that affect adults' behavior (for a review, see Gifford & Hine, 1997). For instance, the time trap can be prevented when withdrawal of the resource is limited: If individuals are not allowed to take the maximum of the resource, they act more sustainably (Cardenas, Stranlund & Willis, 2000; Samuelson & Messick, 1986). A similar effect can be achieved when individuals themselves negotiate the rules they will commit to, and choose one person of their group who controls the compliance with these rules (Ostrom, 1990). If a resource dilemma is played individually, the social trap is avoided and single players act more sustainably than players in a group (Messick & McClelland, 1983). This is also in line with the finding that individuals act more sustainably if each player in a group has a predetermined territory (Cass & Edney, 1978). Finally, communication between players in a group setting helps to prevent selfish behavior and promotes socially-oriented, sustainable behavior among adults (Brechner, 1977; Dawes, McTavish, & Shaklee, 1977; Jorgenson & Papciak, 1981). Interestingly, communication between players has an even more beneficial effect than providing the players with information concerning the optimal strategy (Edney & Harper, 1978). However, whether and how these factors affect children's sustainable behavior in resource dilemmas has not yet been investigated. This is therefore one aim of the present study.

A prominent paradigm emulating a resource dilemma is the fishing conflict game, which has often been used to investigate adults' ecologically sustainable behavior (Nerb, Spada, & Ernst, 1997; Spada & Opwis, 1985; Spada, Opwis, Donnen, Schwiersch, & Ernst, 1987). This game is a variant of a commons dilemma (Hardin, 1968), including a common resource (i.e., a fishing ground) that is used by a number of individuals. In the original version of the fishing conflict game, three players represent fishers who have to decide simultaneously which percentage of the initial quantity of fish they intend to catch in each round representing one season. The maximum catch is limited to 25% per player. The players are neither informed how many fish exist in the beginning nor how many rounds (i.e., seasons) they are going to play. Communication between the players is not allowed. It is only in the course of the game that they come to realize how their fishing behavior and the propagation of the fish population are related, and that there is a dilemma. Criteria for success take into account both individual and group gains. They include the quantity of caught fish per player, the quantity of caught fish per group, and the quantity of fish remaining in the lake after the end of the game.

A simpler game, based on the structure of resource dilemmas, is the *nuts game* (Edney, 1979), where a group of players has access to a bowl containing a certain quantity of nuts that is doubled after a fixed period of time. The players are allowed to withdraw as many nuts as they want, and to exchange them with a reward when the game is over. The game is terminated either when the bowl is empty or after a fixed time limit. Edney found in his pilot work that about 65% of the groups, consisting of college students, exhausted the pool before the first replenishment took place. Gifford (1982) played this game with children and adolescents between 3 and 16 years old. He computed a Harvest Index as indicator of the cooperation between players in the dilemma and, thereby, of the sustainable use of the common resource. The Harvest Index was calculated by standardizing and summing up the total number of harvested nuts in each game, the total quantity of replenishment, and the number of rounds followed by replenishment. The Harvest Index increased with age but it may be questioned whether the Harvest Index does in fact represent a valid variable to reflect sustainable behavior as it increases with the total number of harvested nuts. Thus, a larger harvest might also imply a greater risk of exhausting the resource and a stronger pursuit of individual gains. It might therefore be more instructive to determine an optimal harvest that assures the largest profit for the individual while keeping the resource at least constant over time.

Such an index was implemented in the present study. We used a simplified version of the fishing conflict game (Spada & Opwis, 1985) in which we also adopted aspects of Edney's (1979) nuts game to investigate children's sustainable behavior and by which factors it is affected. Children between six and eleven years old, attending primary school, were chosen for several reasons: First of all, in this age period, a developmental shift occurs from viewing nature as serving humans' wellbeing to realizing the inherent value of nature (e.g., Kahn & Friedman, 1995). In addition, children acquire a better understanding of the complex environmental relationships in this age period (Palmer & Suggate, 2004), and many of the factors related to behavior in social / commons dilemmas as stated earlier are still developing in this age group. Nevertheless, studies in this field with children of this age are still rare (Rickinson, 2010).

Main aims of the current study

We examined (1) whether children, given their still developing cognitive and social skills and self-control, are successful at all in the fishing conflict game in terms of using the resource effectively – or whether the resource breaks down at an early point in time (cf. Edney, 1979), (2) whether children's sustainable behavior is affected by similar factors as that of adults, and (3) whether children's sustainable behavior can be predicted by other individual characteristics.

Children's sustainable behavior was inferred from the number of rounds they played until the resource was exhausted and from their fishing index (see Results). With regard to the second aim, we included three manipulations in order to test whether they yielded similar effects as reported for adults or not: (a) Children played alone versus in groups of three, (b) they were told that there was a fishing limit per round or not, and (c) they were allowed to communicate or not. If these factors yield effects in children, too, they would provide a beneficial foundation for developing environment-related intervention programs for children.

With regard to the game setting, adults act more sustainably if they play alone than in a group (see Cass & Edney, 1978; Messick & McClelland, 1983). We expected a similar effect for children, as the individual game is less complex, the consequences of one's own behavior are easier to anticipate, and children's behavior in the individual setting is not affected by that of co-players in terms of competition.

Second, we expected that a catching limit would have a particularly strong effect on children's sustainable behavior. We believe that children's internal behavioral self-regulation is insufficient in the unlimited version of the resource dilemma, leading to a rapid extinction of the resource right at the beginning of the game (for similar results with adults, see the pilot study of Edney, 1979; cf. Gifford, 1982, who included two practice periods to prevent children from taking all nuts on the first occasion). The original version of the fishing conflict game in fact included only limited withdrawal (Spada & Opwis, 1985). In adults, a direct comparison between a limited and an unlimited version of a resource dilemma showed – perhaps contrary to what one would expect – that the limitation led to more self-oriented and less group-oriented behavior (Cardenas et al., 2000). However, in that study, all participants first completed the unlimited version and then the limited version, thus, the prior experience with the unlimited version might account for this result. In our study, the order of the limited and unlimited versions of the group games was balanced between children.

Third, we presumed that – if the children played in groups – communication would diminish competitive, selfish behavior and support more social-oriented and thereby sustainable behavior (Bornstein, 1992; Dawes et al., 1977). However, this aspect has to be tested empirically as previous research on the role of communication in social dilemmas showed that the quality of the communication increased significantly between childhood and adulthood (Keller & Canz, 2007). Thus, a less complex and less targeted communication might also limit its effects on the behavior of the group members.

With regard to the third aim of the study (i.e., explaining additional variance of children's sustainable behavior), we assessed children's *delay of gratification*, their *conception of fairness*, their *relatedness to nature*, and their most recent *grade in mathematics*. We presumed that children with a greater ability to delay gratification in terms of future-oriented self-regulation (Mischel, Shoda, & Rodriguez, 1989) would act more sustainably in the dilemma, as they would be able to suppress their immediate impulse to harvest as much as possible right at the beginning (i.e., time trap; Hendrickx et al., 2001). In addition, we expected that children with a conception of fairness that accounts for needs and desires of other people in terms of perceiving an equal distribution of goods as fair would behave more cooperatively and less selfishly in this game. Furthermore, feeling closely related to nature should contribute to sustainable behavior as well (see Kaiser, Wölfing, & Fuhrer, 1999; Kals, Schumacher & Montada, 1999; Mayer & Frantz, 2004; Pasca, Aragonés, & Coello, 2017, for results with adults, and Cheng & Monroe, 2012, for results with children). Experiences with nature in childhood are also associated with pro-environmental attitudes and behavior at a later age (e.g., Farmer, Knapp, & Benton, 2007; Wells & Lekies, 2006). Finally, more advanced mathematics skills might enable children to better understand the mathematical rule underlying the replenishment and to optimize their harvesting behavior accordingly (Gummerum et al., 2008).

Method

Sample

The sample consisted of 114 elementary school children (60 girls, 54 boys), aged six to eleven years (*M* = 8.7 years, *SD* = 1.1). They attended two elementary schools and one day-care center in a medium-sized city in Germany. Five children had a non-German background, but all children spoke German fluently. They participated with informed written consent by their parents and could quit the study at any time. Four additional children were tested but played the game only in groups of two and were therefore excluded from the analyses.

Design and Material

We adapted the fishing conflict game by Spada and Opwis (1985) in order to make it suitable for children. The main changes were (a) that real material was used (i.e., toy fish and a toy lake) instead of providing abstract information, (b) that the regeneration rate was simplified (i.e., the remaining quantity of fish was doubled after each round), (c) that the regeneration rate was announced before the experiment started, (d) that the number of rounds was limited to four, and (e) that there was not always a catching limit.

All children played three game sets, each of which could comprise maximally four rounds. The fish population was represented by small wooden fish (length: 2.5 cm) which were placed in a bowl (diameter: 40 cm) that represented the lake. The initial number of fish at the beginning of each game was 15, and the remaining number of fish in the lake was doubled after each round, potentially exceeding the number of 15 if the children caught only few fish. In the first game (Game A), the child played alone and was thus solely responsible for the maintenance of the fish population. Withdrawal was not explicitly limited in this game. In the two other games, three children each were randomly assigned to mixed-sex groups who played together. In Game B, withdrawal of fish was not explicitly limited, while it was explicitly limited in Game C to 25% of the current fish population in the lake per player to ensure maintenance of the lake. Furthermore, children in Game B and C were not allowed to talk in the first three rounds, but encouraged to talk about their fishing aims for one minute before the fourth and last round started. The order of Game B and C was balanced between children.

The experiment followed a 2 (*game setting*: individually vs. in groups; within-subjects) x 2 (*withdrawal*: limited vs. unlimited; within-subjects) x 2 (*communication*: no –

before third round vs. yes – after third round; within-subjects) incompletely crossed design. In addition, individual variables of the children were assessed, which were assumed to be related to their performance in the fishing game. These variables were *delay of gratification, conception of fairness, relatedness to nature,* and *math grade*. The dependent measures were the quantity of fish caught per round and the number of rounds played before the pond was exterminated due to overfishing.

Procedure

The experiment took place in a separate room in children's schools or day-care centers. At the beginning, each child was tested individually. The experiment started with a short introduction by the experimenter, followed by the assessment of the child's *conception of fairness* by means of a variant of the dictator game (Kahneman, Knetsch, & Thaler, 1986; cf. Gummerum, Hanoch, Keller, Parsons, & Hummel, 2010). The experimenter handed six stickers to the child saying that it was a gift for the child's participation, but that there were children at another school who could not participate. If the child wanted, he or she could donate some of the stickers to one of these children. In order to reduce social pressure, the experimenter told the child that she would close her eyes while the child could put the stickers he or she wanted to keep in a white envelope and the stickers he or she wanted to donate to another child (if any) in a brown envelope. Before closing her eyes, the experimenter checked for the child's comprehension by asking again how to use the envelopes. The number of donated stickers served as indicator of the child's fairness. After collecting demographic data including the most recent math grade, the child's *delay of gratification* was assessed. The child was told in a first trial that he or she would receive another reward that would consist of stickers, gummy bears, or cranberries. After the child told the experimenter what he or she would prefer, the experimenter told the child that he or she could now get two pieces of this reward or wait and later in the course of the study get four pieces. The child's decision was noted and the reward was handed over if the child preferred the immediate reward. This was followed by the assessment of the child's *relatedness to nature* by means of 15 items, adapted from the „Connection to Nature Index" (Cheng & Monroe, 2012), which were read aloud by the experimenter. An example item is: "I like to hear different sounds in nature". The child was asked to rate each item by pointing on a 5-point scale that was visualized by colored dots, similar to a traffic light. The scale ranged from "fully agree" (bright green) to "fully disagree" (deep red). The use of the scale and the meanings of the colors were explained to the child in advance, ensuring that the child knew how to deal with the scale.

Then the *fishing game* started with Game A (individual setting, no catching limit). The child was shown the lake and 15 fish and was told to imagine that he or she was a fisher who lives by the lake, that he or she could catch fish in several rounds and that the aim was to catch as many fish as possible in order to support his or her family (cf. Spada & Opwis, 1985). The fish would breed in such a way that the remaining number of fish, after the child had made his or her catch, would be doubled. If only one fish or no fish was left, the fish would not be able to breed and the game would be over. Then the child was asked to write down how many fish he or she would like to catch in the first round and to take the corresponding number off the lake and put them into a box. Thereafter, the experimenter stated the number of caught fish and said how many fish remained in the lake. These fish would then breed and their number would double to x. The new fish were put into the lake by the experimenter, who then asked the child how many fish he or she would like to catch in the next round and to write it down. This procedure was continued until the fourth round. Once the lake held less than two fish, the game was over after the corresponding round.

Game A was followed by a second trial to assess the child's *delay of gratification*. If the child had decided to wait in the first trial, he or she was now told that he or she could get four pieces of the reward right now or wait again to get six pieces later. Then, Game B (group setting, no catching limit) or Game C (group setting, catching limit) started. In the group games, three randomly chosen children played the fishing game together. As in Game A, they first wrote down how many fish they wanted to catch per round and were then allowed to take one after the other of the corresponding number of fish from the lake. Thereafter, the experimenter stated how many fish were caught in total by all players, announced the remaining number of fish, and the new number after the fish population had proliferated. In contrast to the individual setting, children were encouraged to communicate after the third round in Game B and C, and in the game with the catching limit, the experimenter announced at the beginning of each new round how many fish each child was maximally allowed to take. The remaining procedure was the same. After the third game was over, the child who had caught the most fish in each group was identified and was allowed to choose a present (e.g., a small toy). Afterwards, the other two children were allowed to take a present as well. In addition, children who had decided to wait in the delay of gratification test were handed six pieces of the rewards. At the end, all children were thanked for their participation.

Children’s individual characteristics were scored as follows: In the *delay of gratification* test, children received no point if they did not want to wait but demanded two pieces of the reward immediately, one point if they waited until the second occasion to get four pieces of the reward, and two points if they waited until the end of the experiment to get six pieces of the reward. As indicator of children’s *conception of fairness*, it was recorded how many of his or her six stickers each child wanted to donate to another child. Their ratings concerning the questionnaire referring to children’s *relatedness to nature* were scored with 1 to 5 points (larger values indicate a closer relatedness to nature; Cheng & Monroe, 2012). Item analyses revealed that two items yielded poor or negative discriminative power, which were therefore excluded from the further analyses. The remaining 13 items yielded an acceptable internal consistency of Cronbach’s $\alpha = .70$.

Results

Two indicators of sustainable behavior were calculated: (1) the child's fishing index and (2) the number of rounds across which the resource was maintained (see Table 1)[1]. We conceptualized sustainable behavior in this context as catching behavior that keeps the initial quantity of fish constant across the rounds of the game or even increases it. For instance, in the first round of the individual game condition starting with 15 fish, the maximum catch should comprise seven fish to meet this criterion. In this case, eight fish would remain, which would then be doubled, resulting in 16 fish after the proliferation. In the first round of the group game with three children, each child should maximally catch two fish, which leaves nine fish that would be doubled resulting in 18 fish. If each child took three fish in this condition, only six fish would remain and the initial resource would be diminished by three fish at the beginning of the second round. Thus, at least 50% of the initial fish population should optimally remain in the lake, which means that a child in the individual game should not catch more than 50% and each child in the group games should catch maximally 16% of the initial fish population (i.e., 50% divided by three players). This results in the calculation of the optimal fishing amount per round by multiplying the initial number of fish per round by 0.5 in the individual game and by 0.16 in the group games. Children's fishing index was calculated as the mean difference between the optimal fishing amount and their actual catch in each round. The smaller the difference was – in particular if it was negative – the less sustainable children's catching behavior was. Positive values indicate rather restricted fishing, which is beneficial for the fish population but affects the child's individual profit negatively. Values close to zero indicate optimal fishing behavior that includes the maximal gain for a

[1] Please note that the data of ten children in the unlimited group game are missing due to calculation errors of the experimenter or children's unwillingness to conform to the catch restriction rules.

child and, at the same time, guarantees that the resource is treated sustainably. Furthermore, a larger number of played rounds indicates a more sustainable behavior, meaning that the resource was not prematurely extinguished. The fishing index and the number of rounds were moderately but significantly associated in each of the three games: Game A (individual, unlimited withdrawal): $r(114) = .43$; Game B (group, unlimited withdrawal): $r(114) = .34$; Game C (group, limited withdrawal): $r(104) = .39$, $ps < .001$.

Table 1

Indicators of sustainable behavior in each of the three games, separately for each age range

		Age range		
	Game	6-8 years	9 years	10-11 years
Indicator		(n = 50)	(n = 36)	(n = 28)
Number of rounds				
	A	3.64 (0.75)	3.73 (0.61)	3.93 (0.38)
	B	1.10 (0.30)	1.14 (0.35)	1.50 (0.96)
	C	3.81 (0.39)	3.88 (0.33)	4.00 (0.00)
Fishing index				
	A	2.45 (6.33)	1.81 (5.15)	4.03 (5.72)
	B	-5.02 (3.60)	-4.75 (4.31)	-3.57 (3.88)
	C	-0.40 (0.40)	-0.28 (0.54)	-0.26 (0.36)

Note. The total sample was split into three equally large groups according to their age range to illustrate the effect of age. Game A: individual, unlimited withdrawal, Game B: group, unlimited withdrawal, Game C: group, limited withdrawal. The presented fishing index was calculated across all rounds. Standard deviations in parentheses.

First, the number of rounds as one indicator of sustainable behavior in each of the three Games A, B, and C was compared by means of a repeated measures ANOVA with game as within-subjects variable. Game yielded a main effect, $F(2, 206) = 896.64$, $p < .001$, $\eta_p^2 = .90$. Pairwise comparisons (Bonferroni corrected) revealed that when children played individually (Game A) and when they played in a group and the catch was limited (Game C), they maintained the resource across more rounds (Game A: $M = 3.74$, $SD = 0.64$; Game C: $M = 3.88$, $SD = 0.32$)[2] than when they played in a group and the catch was unlimited (Game B). Here, the resource was often extinguished already after the first round (Game B: $M = 1.20$, $SD = 0.58$), ps < .001. Children in Games A and C did not differ concerning the number of played rounds, $p = .14$.

Second, the fishing indices were analyzed. To test the first hypothesis that children in the unlimited individual setting fished more sustainably than in the unlimited group setting, the fishing indices of both groups were compared. In order to keep the data comparable, the mean indices only across the first three rounds were considered because children in the group setting were allowed to communicate after the third round, which did not apply to the individual setting. A repeated measures ANOVA with game (A vs. B) as within-subjects variable revealed a positive fishing index, indicating sustainable behavior, when children played individually ($M = 2.64$, $SD = 5.84$), while the fishing index was negative and significantly smaller, indicating exhausting fishing behavior, when they played in groups ($M = -4.58$, $SD = 3.91$), $F(1, 113) = 155.65$, $p < .001$, $\eta_p = .58$.

[2] One might assume that in the limited group game, children always played four rounds by definition. However, this was not always the case. If only four fish were left at the beginning of the third round and each child took one fish, which was still within the limit (i.e., 25%), only one fish remained, which was – according to the rules of the game and of nature – not sufficient for further proliferation. In these cases (i.e., 21.2%), the game was finished after the third round. Therefore, the mean of the number of rounds in Game C does not equal 4.0.

To test the second hypothesis that children fished more sustainably when they played the limited group game than when they played the unlimited group game, the fishing indices of these two games were compared, including all four rounds as both conditions were comparable with regard to communication between children after the third round. A repeated measures ANOVA with game (B vs. C) as within-subjects variable and the order of the games (limited vs. unlimited first) as between-subjects variable was computed. The analysis confirmed a larger fishing index, approaching zero and thereby reflecting more sustainable behavior, in the limited group game C (M = -0.44, SD = 0.51), as compared to the unlimited group game B where the fishing index was more negative, indicating the exhaustion of the resource (M = -4.44, SD = 4.15), $F(1, 102) = 101.63$, $p < .001$, $\eta^2 = .50$. The order of the games neither yielded a main effect nor an interaction with the game, ps > .69.

In our third hypothesis, we expected that communication after the third round would lead to more sustainable behavior in the group games. Therefore, the fishing indices in the third and fourth round of the group game were compared. This could only be done for the limited condition (i.e., Game C), as in the unlimited condition (i.e., Game B), only three children reached the fourth round. In the other cases, the resource was already depleted at this point. In order to check that a potential improvement was not due to a generally increasing fishing index across played rounds, the index of the second round was considered as well. A repeated measures ANOVA with rounds of the game as within-subjects variable (i.e., 2nd, 3rd, 4th round) revealed a significant effect of round, $F(1.65, 150.09)$[3] = 16.16, $p < .001$, $\eta^2 = .15$, with no significant difference between the second round (M = -0.35, SD = 0.74) and the third round (M = -0.39, SD = 0.51), p = .58 – both without communication – but between the third and fourth round (i.e., after communication; M = 0.11, SD = 0.76), $p < .001$, d = .55, suggesting that communication enhanced children's sustainable behavior.

[3] Greenhouse-Geisser corrected

Finally, we explored whether children's sustainable behavior was associated with children's individual characteristics by means of correlational analyses. The mean values of these characteristics are shown in Table 2. It becomes evident that most children showed a high delay of gratification, waiting until the end of the experiment to get the reward. Furthermore, their relatedness to nature was relatively high. In contrast, their willingness to donate stickers to another child as indicator of their fairness concept and their math grades were in a medium range. In order to rule out effects of social dynamics in the group settings on children's behavior, only the fishing index and the number of rounds in the individual setting (Game A) were considered in the correlational analyses. The only significant correlation was between children's age and their number of played rounds: Older children played more rounds in the unlimited individual game, $r(114) = .22$, $p = .020$. None of the other relationships approached significance[4].

Table 2

Descriptive statistics of children's individual variables

	M		*Min*	*Max*	*n*
Delay of gratification (max.: 2)	1.74	(0.61)	0	2	113
Fairness (max.: 6)	3.61	(1.35)	1	6	113
Relatedness to nature (max.: 65)	57.13	(5.43)	43	65	114
Math grade (max.: 6)	2.09	(0.90)	1	5	90

Note. Standard deviations in parentheses. *Min* and *Max* represent the range of the empirical values that correspond to the range of theoretically possible values with two exceptions: The minimum of children's relatedness to nature and the fairness score could theoretically be 0.

[4] The same analyses were conducted for children's performance in the group games, but again there was no correlation with children's individual variables beyond age, *p*s > .08.

Larger values of grades indicate poorer performance. First graders did not yet receive math grades; the sample is therefore smaller. For one child, delay of gratification and fairness could not be assessed due to time limits.

Discussion

The main aims of this study were to examine whether children between six and eleven years of age can act successfully in a resource dilemma at all, which was a variant of the fishing conflict game, and to assess factors that affect their behavior. We manipulated (1) whether the children played alone or in groups of three, (2) whether the withdrawal of the resource was limited or not, and (3) whether the children in the group settings were allowed to communicate or not. In addition, individual characteristics of the children were assessed that were expected to be associated with their sustainable behavior. In line with findings with adults, children in our study showed more sustainable, resource-conserving behavior when they played alone than when playing in groups (see Messick & McClelland, 1983). Furthermore, they acted more sustainably when withdrawal of the resource was limited (e.g., Cardenas et al., 2000), and when they were allowed to communicate in the group (Brechner, 1977). In addition, older children behaved more sustainably than younger children. Yet, children's sustainable behavior was not related to measures of their delay of gratification, their conception of fairness, their relatedness to nature, and their last grade in mathematics.

The manipulations revealed that children can act sustainably in a resource dilemma, but that their behavior is strongly affected by the context conditions. For instance, they hardly reached the second round of the game if they played in groups and the catch was not limited. This is largely in line with findings of Edney (1979) on playing the nuts game with college students. However, when children played alone, they often maintained the resource across four rounds, even though the catch was not limited. The fishing index confirmed this pattern (Table 1). In addition, descriptive results show that children acted more sustainably in the individual unlimited game, yielding relatively large positive indices compared to the limited group game. However, in the latter condition, the fishing index approached 0, which indicates a better balance between maximizing one's individual gains and maintaining the resource. Thus, children's behavior in the individual condition can be conceived as overcautious – perhaps as they alone felt accountable for the resource. This sensitivity could be built on in interventions that teach children to act sustainably in the group setting as well.

Our results further showed that, even though children's cognitive and social skills as well as their self-control are still developing (see Introduction), similar general patterns were revealed for children between six and eleven years of age as for adults in the resource dilemma. First, like adults, children behaved more sustainably if they used the resource in the unlimited condition alone than when they used it as a group. This is in line with findings that children act more cooperatively in smaller than in larger groups in the context of social dilemmas (e.g., Alencar, De Oliviera Siqueira, & Yamamoto, 2008). Being solely responsible for the resource eliminates the social trap (Messick & McClelland, 1983) because it shows more clearly that withdrawing the maximum at the beginning of the game is at one's own cost. There are no other players who could compensate for the exploitation by taking only a small part of the resource or even nothing. Moreover, in an individual setting, social processes such as social comparisons, leading to competition or envy, are not involved. Thus, decisions concerning the withdrawal in an individual game setting can be made on a quite sound and rational basis, rather than being driven by social emotion and motivation.

Second, the children in our study behaved more sustainably when the withdrawal of the resource was limited than when it was unlimited, which replicates findings with adults (Cardenas et al., 2000). Given that children's self-regulation as one aspect of executive functions is still developing (Jacobson, Williford, & Pianta, 2011; Geldhof, Little, & Colombo, 2010), this finding is plausible and shows that children still depend on external regulation in order to control their behavior – even though adolescents or adults also benefit from external control, but potentially to a smaller degree than children. In addition, it is known that children's temporal discounting is much stronger than that of adolescents and adults (Scheres et al., 2014). Therefore, children might be more prone to walk into the time trap (Messick & McClelland, 1983) by assigning a larger weight to immediate outcomes than to delayed outcomes, even if the delay was rather short in the present paradigm, and the delayed outcomes were more positive than the immediate ones. Applied to resource dilemmas, this means that immediate gains by larger harvests are evaluated more positively by children, even if the long-term costs (i.e., depleting the resource) are considerable.

Interestingly, in the present study we found a ceiling effect concerning children's ability to delay gratification – which is a concept closely related to discounting that was additionally assessed. The majority of children waited until the end of the experiment to get a larger reward instead of choosing an earlier but smaller reward. Nevertheless, there was no relationship between children's delay of gratification and their sustainable behavior in the fishing conflict game. Perhaps the assessment of children's delay of gratification was not sensitive enough to successfully generate sufficient variance between the children and to thereby uncover the relationship with their sustainable behavior in the dilemma (see also Hendrickx et al., 2001).

Third, children acted more sustainably after they were allowed to communicate, and this effect could not be attributed to a general improvement of sustainable behavior across the rounds of the game. Communication, in particular face-to-face communication, has been shown to have strong positive effects on cooperation in social dilemmas (for a review, see Balliet, 2010). Communication allows for the exchange of different perspectives, for the collection and evaluation of behavioral alternatives, and for the coordination of behavior, and is therefore an important basis for successful common actions. Moreover, communication enhances the trust between adult group members (Cohen, Wildschut, & Insko, 2010). It is interesting to see that this effect exists already in children between six and eleven years of age, whose communicative language skills are still developing (Nippold, 2007), in particular those underlying the negotiation with others (e.g., Selman, Beardslee, Hickey Schultz, Krupa, & Podorefsky, 1986). Yet, these skills seem to be sufficient to yield significant effects of communication on children's sustainable behavior in groups (see also Grueneisen & Tomasello, 2017).

Even though we did not assess different age groups, the age range allowed us to exploratorily analyze the role of age. We found that older children acted more sustainably in the resource dilemma in terms of maintaining the resource across more rounds, as compared to younger children. This effect can be attributed to several factors that affect sustainable behavior being closely associated with children's cognitive and self-control development (see Introduction; Kollmuss & Agyeman, 2002). Interestingly, the effect of age was not reflected in the fishing index, which might be due to the relatively large variances of this measure, suggesting that children of the same age act quite differently in the resource dilemma.

Finally, children's individual characteristics besides age were not significantly related to their performance in the dilemma. This is surprising at first sight as it seems plausible to assume these relationships. However, children showed ceiling effects with regard to their delay of gratification and their relatedness to nature, which might explain the absent correlations here. Children's math grades and their conception of fairness, in contrast, showed a broader range of values but still no correlations with their sustainable behavior. Potentially, the mathematical structure underlying the proliferation of the fish resource and the optimal withdrawal rate were too difficult to grasp for the children in our sample, who had not yet formally acquired the concept of exponential growth (but see Ebersbach & Resing, 2008). In addition, children's most recent math grade as an indicator of their math skills might be too different from the mathematical structure of the dilemma and therefore unrelated to children's behavior. A more specific test of the required math skills would have been more suitable. Children's fairness concept was assessed by means of a paradigm in which children could donate parts of a gift they had received to another person. Fairness was conceived as sharing equally between themselves and the other person as no other information (e.g., about the need of the other person) was given. Children who are guided by the principle of equality were expected to cooperate more in resource dilemmas, based on the goal that each partner gets an equal share of the common resource (Bolton & Ockenfels, 2000). However, the context of the game might have also caused the children to take others' actions as a point of reference and to thus act egocentrically when observing such a behavior in others. Therefore, their concept of fairness might be unrelated to children's behavior in resource dilemmas, but more research is needed to support this assumption. It is nevertheless interesting to see that the children's social competence at their age was obviously sufficient to capture the socio-psychological essence of the resource dilemma, possibly because comparison processes are deeply rooted in humans (Barkow, Cosmides, & Tooby, 1995).

Limitations of this study

This study also has some limitations. First, the initial quantity of fish was the same in the individual and in the group version of the game (i.e. 15), implying that in the group version, compared to the individual game, a smaller individual catch could result in the extinction of the resource. Thus, the group game required a more cautious catching behavior in order to maintain the resource. This might be another potential explanation for the better performance in the individual setting. However, the fact that the more individuals are involved in a commons dilemma, the smaller the portion is that each individual can take, is in line with real sharing or cooperation contexts. Moreover, it is the central difference between using a resource alone or with others. The procedure in the current study accounts for this issue. Nevertheless, it might be worthwhile in future research to explicitly manipulate the initial size of the resource as being either equal in the individual and group condition or as being relatively larger in the group condition to examine its effects.

Furthermore, it seems reasonable to assume that further factors might contribute to – or be associated with – the sustainable behavior of children (see Gifford, 2014, for a review;

Kollmuss & Agyeman, 2010; both referring to adults). We focused on some central ones here, but it might be instructive to assess further variables and their potential complex interplay in future research. In this regard, for instance, a more fine-grained analysis of children's interactions when playing in groups might be interesting. Research with adults in social dilemmas has revealed that cooperation decreases across rounds, in particular when cooperative individuals become aware of so called "free-riders" who are only focused on their own gain (e.g., Fehr & Fischbacher, 2003; Ledyard, 1995). One might also analyze how the quality of the communication within the groups changes children's behavior. Finally, a larger sample size and more sensitive measures of children's individual variables might shed light on their contribution to children's sustainable behavior in a commons dilemma.

Implications and future research perspectives

Investigating children's behavior in resource dilemmas may also provide hints for improving their sustainable behavior. We showed that children acted more sustainably when playing alone than when playing in a group. Thus, first experiencing one's own responsibility and the consequences of one's own behavior for a resource in an individual setting might sensitize children for a less impulsive and more sustainable use of the resource. These experiences might thereafter be transferred to a group setting. In the present study, the order of the settings was fixed: Children first played in the individual setting. Future studies might vary the order of the individual and group setting to test this hypothesis. Furthermore, children in the present study benefitted from an external regulation of the withdrawal as part of the rules of the game. One might speculate that first experiencing such a limitation fosters an understanding of the dilemma structure as the resource is not depleted immediately – even though the order in which the children played the limited and unlimited group games did not yield an effect in our study. It might nevertheless be worthwhile in future research to reduce this limitation step by step in order to promote children's internal regulation of the withdrawal.

Finally, communication had a positive effect on children's behavior in the dilemma. It could be concluded that interventions aimed at enhancing children's sustainable use of a common resource might profit from incorporating communication and the exchange of different perspectives as well as the compilation of the knowledge of different people. Positive effects of communication have already been reported for children's moral development (Walker & Hennig, 1999; Walker & Taylor, 1991). Communication can also foster the establishment of positive norms, which may serve to adjust one's own environment-related behavior (for an overview, see New, Savulsecu, & Faber, 2018). This might apply in particular to parents who model positive behavior to their children (e.g., Matthies, Selge, & Klöckner, 2012). Thus, for children it might be important with whom they play the resource dilemma: with peers who may be conceived as competitors or with adults who may serve as positive role models. In future studies, the type of co-players might be varied and it might additionally be worthwhile to analyze the content of the communication to uncover its underlying mechanisms.

Taken together, we showed that children between six and eleven years of age are successful under particular conditions to manage an environmental resource. More specifically, their behavior was more sustainable if they played alone, if the withdrawal was restricted, and if they were allowed to communicate in the group setting. These patterns are largely in line with findings for adults. Given that today's children are the consumers of tomorrow and that children may also influence the environmental behaviors of their parents (cf. Rickinson, 2010), it seems instructive to examine further factors by which their sustainable behavior is affected, and to develop effective interventions that help to improve children's sustainable behavior.

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