# A Developmental Perspective on Option Generation and Selection: Children Conform to the Predictions of the Take-the-First Heuristic

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## Abstract

Little is known about how children generate options for taking action in real-life situations or how they select which action option to actually perform. In this paper, we explore the interplay between option generation and selection from a developmental perspective using sport as a testbed. In a longitudinal design with four measurement waves, we asked 6- to 13-year-olds (*N* = 73) to generate and select action options in a soccer-related task. Children conformed to predictions of the Take-the-First heuristic: They generated only a few options in decreasing order of validity (i.e., better options were generated earlier) and selected the first options they had generated. Older children selected the first option generated more often than younger children and generated options faster. Longitudinal effects revealed that both age groups generated fewer options and faster across waves. Time limitation fostered fewer and higher quality options being generated and selected. Overall, our results highlight the importance of considering the predecisional process of option generation to deepen our understanding of developmental changes in decision strategy use. Future research directions and implications for children's real-life decision making are discussed.

*Keywords:* option generation, option selection, Take-the-First heuristic, decision making, cognitive development

# A Developmental Perspective on Option Generation and Selection: Children Conform to the Predictions of the Take-the-First Heuristic

Imagine being a young, talented soccer player. You are running through the midfield toward the goal, dribbling past one opponent after another. You are now 20 m from the goal, facing the opposing defense rapidly closing on you. What could you do? Shoot at the goal from where you are? Or should you pass the ball to one of your teammates—maybe the one approaching from the left? Making good and quick decisions is essential in sports, as in many other domains (Raab & Gigerenzer, 2015). Most often in real life, before actually deciding what to do, one has to think about what *could* be done, generating and simulating alternative actions that could be taken and imagining how possible scenarios could be played out.

Little is known about how decision-making strategies develop across childhood, and even less—if anything—is known about how children generate action or decision options and select among them. In this paper, we explore for the first time the interplay between option generation and selection, crucial building blocks of decision making, from a developmental perspective, using sports as a testbed.

## The Developing Decision Maker

Most decision-making studies have focused either on adults or on the aging decision maker (Horn, Pachur, & Mata, 2015; Mata et al., 2012; Mata, Schooler, & Rieskamp, 2007). *Developing* decision makers, that is, children, have rarely been studied, and therefore the development of decision-making abilities across childhood is still poorly understood (Klaczynski, 2001). Decision-making research with children has focused on predecisional information search (i.e., the information children spontaneously ask for; see Ruggeri & Katsikopoulos, 2013; Ruggeri, Olsson, & Katsikopoulos, 2015; or the information children select from a set of informational items; see Davidson, 1991, 1996; Gregan-Paxton & Roedder John, 1995) or has investigated cue-based decision strategies (Betsch, Lehmann, Lindow, Lang, & Schoemann, 2016; Horn, Ruggeri, & Pachur, 2016; Mata, von Helversen,

& Rieskamp, 2011). Previous studies found that younger children (7- to 9-year-olds), compared to older children (10- to 12-year-olds) and adults, tended to search for more *irrelevant* information (Davidson, 1991), preferred more information-intensive strategies (e.g., strategies that collect and integrate all the information available), and had a harder time focusing on one or a few most informative cues when making decisions (Mata et al., 2011). Along the same lines, a recent study by Betsch and colleagues (Betsch et al., 2016) showed that neither preschoolers' nor primary school children's search was guided by the informativeness of the given cues.

To our knowledge, *option generation*, that is, the process of generating alternative action or decision options from which to select, has never been studied in children before. How many options do children generate and consider before making a selection? How *good* are those generated options, and are they generated in a random fashion or is the generation process systematic? Children start at an early age to make decisions for which they need to consider alternative options: what food to buy at the school canteen, what game to play, what club or hobby to commit to, what way to walk to school. Understanding the way children come up with and select alternative actions or decision options can shed light on the development of their decision-making strategies. We consider the development of decision-making strategies from an ecological rationality perspective. Within this framework, strategies are not good or bad per se, but rather, their effectiveness depends on the cognitive abilities of the decision-making agent, as well as on the characteristics of the environment considered. Thus, when studying the developing decision maker it is crucial to consider "the individual and [his or her] particular stage of ontogenetic development" (Todd, Gigerenzer, & the ABC Research Group, 2012, p. 11), also because the developmental stage influences the effect a given environment has on a person's use of heuristics (Marasso, Laborde, Bardaglio, & Raab, 2014).

## Option Generation and the Take-the-First Heuristic

A decision-making strategy usually consists of a search, a stop, and a decision rule, which together define how and how much information has to be collected before one can make a decision (Gigerenzer, Todd, & the ABC Research Group, 1999). However, most real-world situations require people to generate alternative options *before* making a decision, rather than selecting one from a set of predefined options offered by an experimenter (Payne, Bettmann, & Johnson, 1988). Option generation has previously been studied with adults and adolescents in sports (Johnson & Raab, 2003; Raab & Johnson, 2007). Indeed, because of its naturally occurring dynamics (e.g., decisions to be made under time pressure; many potential alternative actions to be considered), sports is the ideal domain to test whether people use fast-and-frugal heuristics, such as the Take-the-First (TTF) heuristic (Raab, 2012; Raab & Gigerenzer, 2015).

The TTF heuristic is a cognitive model that captures option generation and decision making in familiar yet ill-defined tasks (Johnson & Raab, 2003; Raab, 2012; Raab & Johnson, 2007). The building blocks of TTF are formally defined as follows: a *search rule,* which generates options in order of validity (i.e., better options generated earlier), so that subjectively better options are generated earlier; a *stop rule,* according to which the generation phase should stop after two or three options have been generated; and a *decision rule,* according to which people should select one of the initial options generated (Johnson & Raab, 2003). Following TTF, people would generate only a few options and select the first one generated, rather than exhaustively generating and processing all possible options. Because these options were generated in order of validity, the decision, although fast and frugal, would tend to be accurate. Empirical studies have shown that the performance of experienced handball (Johnson & Raab, 2003), basketball (Hepler & Feltz, 2012), and soccer (Belling, Suss, & Ward, 2015) players is quite accurately predicted by the TTF heuristic:

Players generated about two options (e.g., shoot at the goal or pass to a teammate) in order of validity and selected the first option generated as the final decision.

## Time-Limitation Effects on Option Generation and Decision Making

According to the ecological rationality framework (Todd et al., 2012), no strategy is *always* optimal, because the efficiency of a strategy depends on the environmental structure. In this sense, people should be *adaptive* and modify their strategies depending on how effective they are in a given environment. In many real-life situations, as in sports, decisions have to be made under limited time, and adults have been shown to adapt to time limitation by using faster and simpler strategies (Ben Zur & Brenitz, 1981; Payne et al., 1988). Along the same lines, in a study with adult soccer players, Belling and colleagues (2015) found that time limitation reduced the number of task-relevant options generated, although it did not impact the quality of players' decisions.

What about the effects of time limitation on the performance of developing decision makers? We know that children are *ecological learners*—they adapt their learning strategies to the characteristics (e.g., the statistical structure) of the task at hand (Horn et al., 2016; Nelson, Divjak, Gudmundsdottir, Martignon, & Meder, 2014; Ruggeri & Lombrozo, 2015), and they do so already by age 4 years (Ruggeri, Sim, & Xu, 2017). However, Davidson (1996) investigated the influence of time limitation on children's (7- to 10-year-olds) information search behavior and found that time pressure promoted faster, but generally not more selective searching.

## The Present Study

In the present study we examined the development of children's option generation and selection by testing 6- to 13-year-old soccer players. In particular, we investigated whether children's option generation (search and stop rules) conformed to the predictions of the TTF heuristic. Additionally we tested the decision rule of TTF against other decision models: the random selection model, where the action to perform is chosen randomly from the set of generated options; the Take-the-Best-Option heuristic, which predicts that children will select the best option (i.e., the option with the highest quality) among those generated; and the Take-the-Last heuristic, which predicts the selection of the last generated option. As children have been shown to use simple, noncompensatory information-search strategies (Bereby-Meyer, Assor, & Katz, 2004; Ruggeri & Katsikopoulos, 2013) and adolescent handball players have been shown to act according to TTF (Johnson & Raab, 2003), we expected children to make use of the TTF heuristic in a familiar real-life task. Taking into account previous developmental studies showing an increase in selective, noncompensatory strategy use with age (Davidson, 1991, 1996; Mata et al., 2011), we also expected older children to be more likely to conform to the predictions of TTF compared to younger children.

Whereas previous research has mainly used cross-sectional designs, in the present study we implemented a longitudinal design similar to that of Raab and Johnson (2007) that allowed us to monitor strategy change over time. We expected children to increase their reliance on fast-and-frugal heuristics across waves as they gained more experience with the task (cf. Raab & Johnson, 2007). More precisely, with a focus on the individual building blocks of TTF, we predicted that children would generate options faster (search rule; Raab & Johnson, 2007) and would generate fewer options (stop rule) across waves. Whether children would select the first option as their final choice more often across waves (decision rule) is more difficult to predict: Although theoretically an increase in experience should lead to selecting the first option more often as the final choice (Johnson & Raab, 2003; Raab & Johnson, 2007), no changes were found in the longitudinal study with adolescents (Raab & Johnson, 2007). Moreover, considering the general information-search literature that shows an increase in both a tendency to ignore irrelevant information and a selective focus on more informative cues across childhood (Davidson, 1991; Gregan-Paxton & Roedder John, 1995; Mata et al., 2011), we expected children to generate and select higher quality options across waves.

Finally, we explored whether and how time limitation influences children's option generation and selection. From the literature reviewed above it is unclear whether and how children would adapt their option generation and selection depending on the time available.

# Method

## Participants

A total of 98 boys, recruited from a professional soccer academy in XXXXX, participated in this study. Using G-Power sample size estimation (Faul, Erdfelder, Buchner, & Lang, 2009), we estimated needing a sample of 66 participants ($\alpha$ = .05, 1−$\beta$ = 0.80, *f* = 0.42 in the study of Belling et al., 2015). We recruited 98 participants to account for an expected dropout rate of about 25% across waves (cf. longitudinal study by Raab & Johnson, 2007). Of the original sample, 73 completed all four measurement waves and were consequently included in the analyses: 38 younger children belonging to the Under-11 teams (*M* = 8.73 years; *SD* = 1.15 years; range = 6.67 to 10.50 years) and 35 older children belonging to the Under-14 teams (*M* = 12.37 years; *SD* = 0.81 years; range = 10.92 to 13.50 years).

Most children (*n* = 65, 90%) were XXXXX; all children were XXXXX speaking and lived in or near a large city in western XXXXX. Before the start of the study, written informed consent was obtained from participants' parents and the local ethical review board approved the study protocol (XXXXXXXXXXX).

## Materials

We used 21 video scenes of live soccer match footage (three for the practice trials, 18 for the test trials). We adopted the same task and materials as in Belling et al. (2015): After a short display of buildup play, the scenes suddenly stopped with a frozen frame, right before the player in possession of the ball had to make a decision (see Figure 1). Materials were presented to children on an 8.9" tablet.

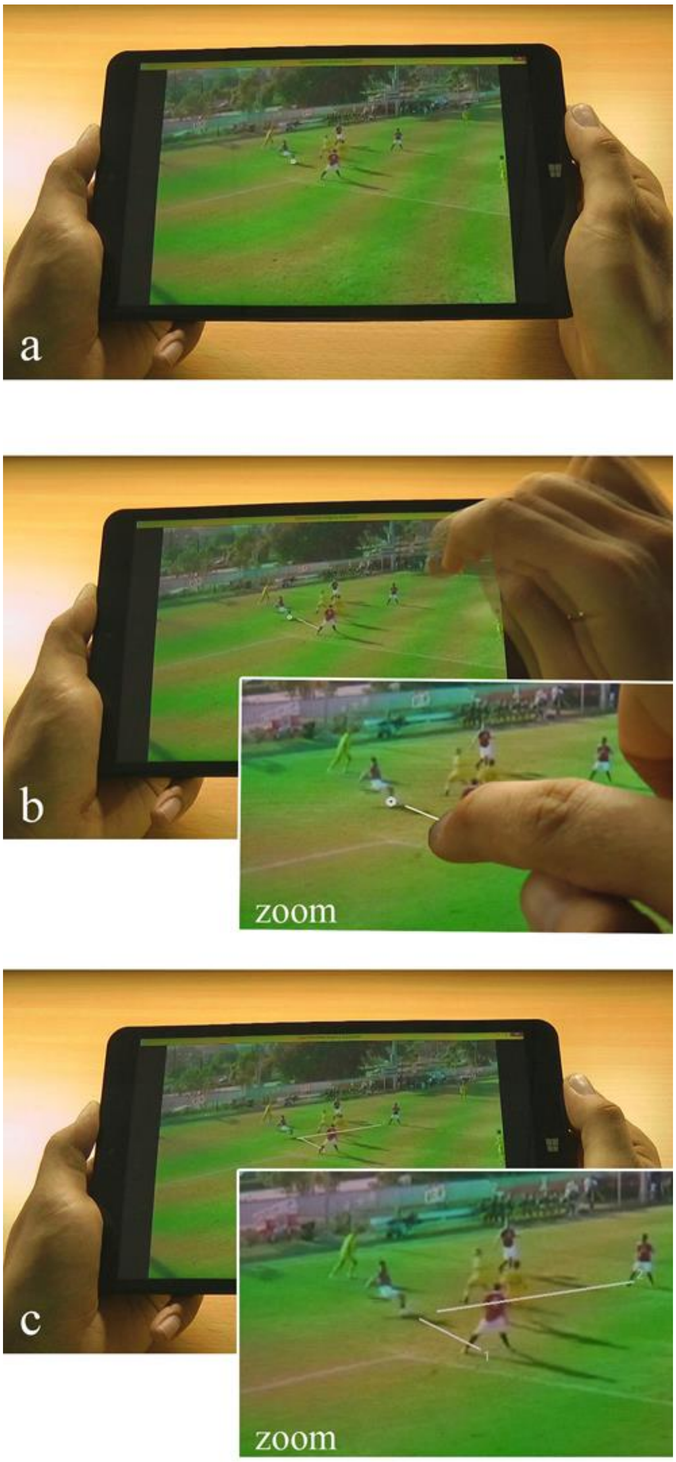


*Figure 1*. Option-generation and selection procedure. (a) After a short display of buildup play, the scene stopped with a frozen frame, right before the player in possession of the ball had to decide which action to take. (b) Children generated alternative actions the player in possession of the ball could take by drawing them on the screen. (c) Children reviewed their generated options and selected the one they thought was the best.

**Design and Procedure**

We conducted the present study in a longitudinal cohort design (Schaie & Baltes, 1975), in which two age groups of children were tested in four waves at intervals of 6 months (referred to as t1–t4; Wave 1: August 2015, Wave 2: February 2016, Wave 3: August 2016, Wave 4: February 2017). Overall, the study included three factors: measurement wave (four levels: t1–t4) and time limitation (two levels: short- or long-time condition) as within-subject factors, and age group (two levels: younger or older children) as between-subjects factor, resulting in a 4 × 2 × 2 design.

The task was administered to groups of five to nine same-aged children in a quiet room located at the soccer academy. Children, sitting alone at individual desks where a tablet was positioned, were introduced to the task procedure via a standardized instructional video (duration: 2:51 min) that was meant to familiarize them with the tablet and the task by walking them through the testing procedure. The experimental session consisted of 21 trials: The first three were practice trials, where children could ask the experimenter to clarify any questions. Only the results of the 18 test trials were included in the analyses. Each trial comprised two phases: option generation and option selection.

**Option generation.** On each trial, children were presented with a video of buildup play that stopped and held on a frame (see Figure 1 and Materials presented above). Children were then asked to generate a maximum of six action options (e.g., pass to the player on the right; dribble; shoot) directly marking them on the field using the touch screen (see Figure 1a and b). Trials were randomly assigned to either the short-time (9 trials) or the long-time (9 trials) condition. In the long-time trials children were given 30 s to generate options, whereas in the short-time trials they were given 7.5 s to generate options. The order of presentation of the test trials was randomized.

**Option selection.** Children were presented with the action options they had generated in the previous phase and were asked to select the best option among these (see Figure 1c).

**Coding**

To assess the quality of the options generated and selected, two experienced youth soccer coaches, blind to the experimental hypotheses, independently evaluated all the options the children had generated for the 18 test trials. Both coaches had a UEFA B-level coaching license and at least 10 years of experience coaching a youth soccer team. For each of the 18 test trials, presented in random order, coaches were asked to rate the options on a 10-point scale (from 1, 'not at all good', to 10, 'very good'). Having obtained good interrater agreement for the best option (Krippendorff's Kappa = .82, $p = .01$, intraclass correlation coefficient [*ICC*] = .77, $p < .001$) and quality of all options generated ($r = .56$, $p = .01$, ICC = .67, $p < .001$), we computed the quality scores for each generated option by averaging coaches' quality ratings**.**

## Results

First, we performed separate linear mixed-models analyses to investigate the effects of age group (two levels: younger vs. older children) as a between-subjects variable and wave (four levels: t1, t2, t3, t4) and time limitation (two levels: short-time vs. long-time) as within-subjects variables on four outcomes: (1) mean number of options generated across the 18 test trials; (2) average time taken to generate the first option; (3) average quality across all the generated options; and (4) average quality across all the selected options. Second, we interpreted the results in light of the predictions of the TTF heuristic (see above), further comparing them against predictions of the random selection model, the Take-the-Best-Option heuristic, and the Take-the-Last heuristic.

## Option Generation

**Number of options generated.** Overall, in line with TTF, children stopped their generation after a mean of two options (1.92 options, $SD$ = 0.99). In 41.3% ($n$ = 2,125) of all trials, exactly two options were generated and in 35% ($n$ = 1,822) of all trials, only one option was generated. Older and younger children did not differ in the number of trials in which they generated exactly two options (younger children: 33.6%; older children: 49.5%; $p$ = .081). However, a chi-square test showed that older children generated only one option in fewer trials (24%) compared to younger children (45.7%), $\chi^2(1) = 6.47$, $p$ = .011, Cramér's V = 0.30. Also, in 2.1% ($n$ = 111) of all trials no options were generated. Older and younger children did not differ in the number of trials for which they generated no options (younger children: 1.4%; older children: 0.7%; $p$ = .629).

Our analysis revealed no effect of age group ($p$ = .583), but we did find main effects of wave ($B$ = -0.22, $p$ < .001) and time limitation ($B$ = -0.75, $p$ < .001) on the number of options generated, as well as a Wave × Time Limitation interaction ($B$ = 0.14, $p$ < .001). In particular, the analysis showed that fewer options were generated across waves ($M_{t1}$ = 2.08, $SD$ = 1.19; $M_{t2}$ = 2.09, $SD$ = 1.00; $M_{t3}$ = 1.80, $SD$ = 0.86; $M_{t4}$ = 1.73, $SD$ = 0.80) and that in the short-time condition children generated fewer options ($M_{short}$ = 1.70, $SD$ = 0.84) than in the long-time condition ($M_{long}$ = 2.15, $SD$ = 1.07). Moreover, the interaction effect revealed that in the long-time condition the number of options generated decreased across waves more dramatically than in the short-time condition, $t(1195) = 9.44$, $p$ < .001, $d$ = 0.52 (see Figure 2).

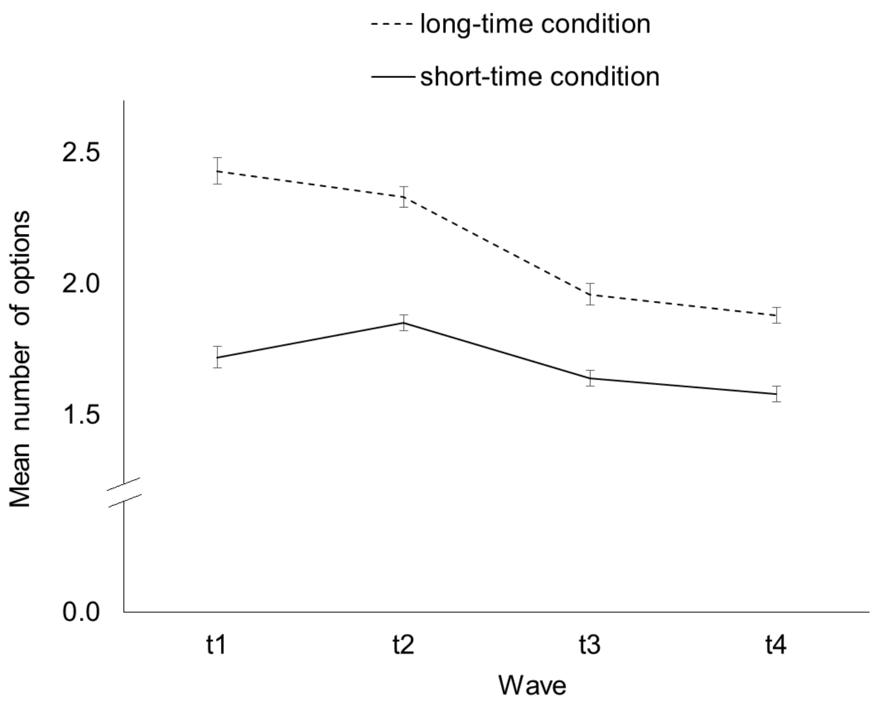


*Figure 2.* Number of options generated across waves (t1–t4) in the long-time and short-time conditions. Error bars represent one SEM in each direction.

**Generation time of the first option generated.** The mean generation time of the first option was 741.18 ms (*SD* = 386.11 ms). All fixed factors—age group ($B = 87.48$, $p = .024$), wave ($B = -42.6$, $p < .001$), and time limitation ($B = -97.59$, $p < .001$)—influenced the generation time of the first option. Older children ($M_{\text{older}}$ = 691.70 ms, *SD* = 351.91 ms) generated the first option faster than younger children ($M_{\text{younger}}$ = 786.96 ms, *SD* =410.10 ms). Options were generated faster across waves ($M_{t1}$ = 827.29 ms, *SD* = 446.09 ms; $M_{t2}$ = 735.36 ms, *SD* = 378.99 ms; $M_{t3}$ = 703.12 ms, *SD* = 360.48 ms; $M_{t4}$ = 700.19 ms, *SD* = 338.54 ms) and in the short-time condition ($M_{\text{short}}$ = 689.68 ms, *SD* = 339.75; $M_{\text{long}}$ = 790.70 ms, *SD* = 420.24 ms). No interactions between the fixed factors were apparent.

**Quality of the generated options.** The mean quality across all generated options was 4.62 (*SD* = 2.79). The analysis revealed no effect of age group ($B = -0.14$, $p = .623$) or wave ($B = 0.05$, $p = .468$) but did reveal a main effect of time limitation. The quality of all options generated was higher in the short-time condition ($M_{short} = 5.26$, $SD = 2.79$) than in the long-time condition ($M_{long} = 4.00$, $SD = 2.65$; $B = 1.3$, $p < .001$).

The first option generated had a mean quality of 5.20 (*SD* = 3.48). The quality of the first option generated was not affected by age group ($p = .951$) or wave ($p = .328$) but was affected by time limitation ($B = 1.00$, $p < .001$). Overall, children generated options of higher quality in the short-time ($M_{short} = 5.71$, $SD = 3.36$) compared to the long-time ($M_{long} = 4.71$, $SD = 3.53$) condition.

As predicted by TTF, children generated options in order of validity, which was confirmed by a repeated measures analysis of variance (ANOVA). The quality of the first three options generated differed significantly across serial positions[1], Greenhouse–Geisser $F(1.46, 361.29) = 188.33$, $p < .001$, $\eta_p^2 = .43$: The first options generated were of higher quality ($M = 5.23$, $SD = 0.93$) compared to the second ($M = 3.60$, $SD = 1.21$), $F(1, 248) = 401.96$, $p < .001$, $\eta_p^2 = .62$, and third options ($M = 2.83$, $SD = 2.07$), $F(1, 248) = 315.33$, $p < .001$, $\eta_p^2 = .56$. Children of both age groups generated options in order of validity as no age differences were apparent when considering the interaction with age group ($p = .557$). The same pattern of results was also apparent when each wave was analyzed separately (please refer to the section S1 of the supplemental materials for the results reported by wave).

Our additional analysis revealed that the more options children generated, the less often their first option generated was the best of all their options, $\chi^2(4) = 317.84$, $p < .001$, Cramér's V = .31. While children's first option generated was the best in 27.6% of the trials in which two options were generated, this was the case in only 3.4% and 0.5% for three and

[1] We considered only those trials in which up to three options were generated (93%) to avoid the problem of too many missing points invalidating the results of the ANOVA.

four options generated, respectively. When five or six options were generated, the first option selected was never the best. The same trend was apparent for both, the younger ($\chi^2(4)$ = 115.87, $p$ < .001, Cramér's V = .28) and the older age group ($\chi^2(4)$ = 199.57, $p$ < .001, Cramér's V = .33).

**Option Selection**

**Quality of the selected option.** The mean quality of the options selected across trials was 5.00 (*SD* = 3.56). Our analysis revealed no main effects of age group ($p$ = .592) or wave ($p$ = .231) on the quality of the final option selected. However, we found a main effect of time limitation ($B$ = 0.79, $p$ < .001): Children selected options of higher quality in the short-time ($M_{short}$ = 5.39, *SD* = 3.51) compared to the long-time ($M_{long}$ = 4.60, *SD* = 3.56) condition.

**First option generated selected as final option.** Overall, children selected the first option they had generated as their final option in 75.9% of all trials and in 62.7% of trials in which more than one option was generated. Children selected options they had generated at earlier serial positions, particularly their first option generated, more often compared to options generated later in the generation phase (for all trials: all Cramér's V > .68; for trials with more than one option generated: all Cramér's V > .59). Generally, as predicted by the TTF decision rule, children selected the first option generated in more than 50% of the trials (for all trials: all Cramér's V > .43; for trials with more than one option generated: all Cramér's V > .22) and did so less often, the more options they generated ($r$ < –.38, all $p$ < .001; see Table 1).

Considering only the trials in which more than one option was generated, neither wave ($p$ = .770) nor time limitation ($p$ = .694) had a significant impact on whether children selected the first as final option, but age group did (*OR* = 0.6, $p$ < .001). Older children ($M_{older}$ = 67%, *SD* = 47%) selected the first as final option significantly more often compared to younger children ($M_{younger}$ = 57%, *SD* = 50%).

Table 1

*Absolute Frequency of Selected Options Displayed by Serial Position and Number of Generated Options*

| Number of generated options | Serial position of the selected option | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | 1,822 | 0 | 0 | 0 | 0 | 0 | 1,822 |
| 2 | 1,461 | 664 | 0 | 0 | 0 | 0 | 2,125 |
| 3 | 472 | 223 | 190 | 0 | 0 | 0 | 885 |
| 4 | 110 | 31 | 27 | 45 | 0 | 0 | 213 |
| 5 | 26 | 11 | 9 | 8 | 8 | 0 | 62 |
| 6 | 14 | 7 | 3 | 4 | 2 | 8 | 38 |
| Total $n_{\text{all trials}}$ | 3,905 | 936 | 229 | 57 | 10 | 8 | 5,145 |
| Total $\%_{\text{all trials}}$ | 75.9% | 18.2% | 4.5% | 1.1% | 0.2% | 0.2% | 100.0% |
| Total $n_{\text{trials in which more than one option was generated}}$ | 2,083 | 936 | 229 | 57 | 10 | 8 | 3,323 |
| Total $\%_{\text{trials in which more than one option was generated}}$ | 62.7% | 28.2% | 6.9% | 1.7% | 0.3% | 0.2% | 100.0% |

**Model comparison.** Considering only those trials in which more than one option was generated, children selected the best (i.e., highest quality) among the generated options (Take-the-Best-Option heuristic) in 24.4% of the trials. In 18.6% of the trials, taking the best option meant following the TTF decision rule; in 5.8% of the trials, children selected the best but not the first among their options generated, and in 44.1% of the trials, they selected the first but not the best option. Children selected their *last* option in 27.5% in trials. Selection of the last option never corresponded to the TTF decision, by definition.

Overall, children selected the first option more often compared to what was predicted by the random selection model, $t(3322) = 23.78$, $p < .001$, $d = 0.41$; the Take-the-Best-Option model (24.4%), $\chi^2(1) = 559.08$, $p = .003$, Cramér's V = .43; and the Take-the-Last model (27.5%), $\chi^2(1) = 455.04$, $p = .001$, Cramér's V = .39. Please refer to Tables S1.2 and S1.3 in the supplemental materials for results of the model comparison reported by wave.

In an additional exploratory analysis, we tested whether an increasing number of options generated decreased the likelihood of selecting the first, best, and last option. Results showed that the more options children generated, the less often they selected their first ($\chi^2(4) = 99.90$, $p < .001$, Cramér's V = .17), best ($\chi^2(4) = 452.40$, $p < .001$, Cramér's V = .37), and last option ($\chi^2(4) = 42.83$, $p < .001$, Cramér's V = .11). The same pattern emerged for both age groups. Irrespective of the number of options generated, older children selected the first option generated when it was the best one more often (21.4%) than younger children (15.4%), $\chi^2(1) = 17.50$, $p < .001$, Cramér's V = .07.

## Discussion

Little is known about how children generate and select options for taking action in real-life situations. In this paper we explored the interplay of option generation and selection, crucial building blocks of decision making, from a developmental perspective, testing children in a sport-specific task. In particular, taking an ecological rationality perspective, we tested whether the TTF heuristic could predict children's option generation and selection better than other cognitive models.

### Children Use the TTF Heuristic

Our results showed that children's option generation and selection generally conformed to the predictions of the TTF heuristic: They generated on average about two options per trial and generated them in a meaningful way, that is, producing higher quality options first. That children did apply the TTF heuristic in a real-life decision-taking task is consistent with findings showing that even school-aged children use decision heuristics that match the task at hand (e.g., Horn et al., 2016) and results demonstrating children's use of simple, noncompensatory information-search strategies (Bereby-Meyer et al., 2004; Ruggeri & Katsikopoulos, 2013).

Children's option generation influenced their final selection: For both younger and older children, the more options they generated, the less often they selected the first option.

This pattern, that is, the mismatch between the first option generated and the one selected, has been referred to as *dynamic inconsistency* and has been shown to increase with the number of options generated (Johnson & Raab, 2003; Raab & Johnson, 2007). Thus, our results indicate that the decision rule children apply depends, at least to some degree, on their stop rule, such that children's decisions are more dynamically inconsistent when they stop later, after having generated more options. Recent research has identified the stop rule as a crucial factor responsible for younger children's general lower efficiency in information search compared to that of adults (Ruggeri, Lombrozo, Griffiths, & Xu, 2016). On the same line, in the present study children were more efficient when they had generated fewer options: The more options younger and older children generated, the less likely they were to select the first or the best option. Importantly, children's first option selected was also less likely to be the best the more options they had generated, which was true for younger and older children alike.

That children do indeed use the TTF heuristic was further supported by our model comparisons: Children's selection was more consistent with the predictions of TTF, compared to the random, Take-the-Best-Option, or Take-the-Last models. Importantly, children selected the first option in most of the decisions made.

Although the number and quality of options generated did not differ between age groups, older children generated options faster. As hypothesized, older children selected the first option generated more often than younger children. These results can be interpreted as an indication of older children having a stronger and more selective decision rule and are in agreement with previous findings showing that preschoolers and elementary school children are not yet able to selectively attend to the most relevant information (Betsch et al., 2016; Mata et al., 2011). The results further document a shift to a more pronounced use of noncompensatory strategies by the age of 11 years (Mata et al., 2011). Importantly, our results underline that following the simple decision rule by "taking the first" did not always yield to selecting of the best option. Indeed, selecting the first option did not lead children to select the best option in many (44.1%) of the trials. Finally, although no age differences emerged for the quality of the options generated or selected, we observed that older children selected their first option generated when it was the best one more often (21.4%) than younger children (15.4%). In this sense, our results suggest that older children's option generation and selection strategies are more effective than those of younger children.

**Longitudinal Effects on Option Generation**

Like the adolescent handball players in the study of Raab and Johnson (2007), children of both age groups in the present study sped up their option generation and generated fewer options across the four measurement waves. However, the quality of the options generated and selected was not affected by wave. Contrary to our predictions, children did not select the first option generated more often across waves and, more generally, seemed not to modify their decision rule in the course of the 1.5-year testing period. This result can be interpreted in at least two different ways, not mutually exclusive. First, the gain in domain-specific experience across waves was not enough to shift the decision rule application (Horn et al., 2016; Raab & Johnson, 2007). In this sense, children's experience across waves might not have been enough for them to learn how to implement more effective selection strategies, also because no feedback was offered. Second, there might have been a ceiling effect: Because the children were already selecting the first option generated at a high percentage in the first measurement wave, the potential to increase their reliance on this decision rule across waves was limited.

**Time Limitation Fosters Better Options and Decisions**

In contrast with the results obtained with adult soccer players (Belling et al., 2015), when less time was available, children generated fewer options and selected options of higher quality. Indeed, in line with the notion of "less-is-more" and in theoretical agreement with the ecological rationality perspective (Johnson & Raab, 2003; Todd et al., 2012), the time constraint prompted the generation of fewer but better options. More generally, our results speak to children's ecological learning, that is, to their ability to adapt their decision strategy to the situation or task at hand (Ruggeri & Lombrozo, 2015; Ruggeri et al., 2017).

Interestingly, an interaction of time limitation and wave also emerged: In the long-time condition the number of options generated decreased across waves more dramatically than in the short-time condition. While children generated fewer options in response to short time at all waves, in the long time condition children adapted their stop rule across waves, eventually converging on the number of options generated in the short time condition. This indicates that children learned, across waves, to constrain themselves during generation when time was available to generate more options, becoming more selective. This result also suggests that children internalized the effectiveness of generating fewer, high quality options.

## Conclusions

The present study shows that 6- to 13-year-old children generate and select options as predicted by the TTF heuristic. Importantly, developmental differences were evident for the decision rule: Older children selected the first option as their final choice more frequently than younger children. Future research should test whether, as we believe is the case, our results generalize to a broader range of dynamic decision tasks children have experience with.

More work is needed to investigate how the interaction of developmental and environmental factors can impact children's predecisional and decisional processes (Marasso et al., 2014; Mata et al., 2012). In particular, it is crucial to understand which and how individual and age-related differences, such as the ability to selectively focus on relevant information or effective information integration (as discussed by Mata et al., 2011) and cognitive flexibility (e.g., task switching; Best & Miller, 2010; Legare, Mills, Souza, Plummer, & Yasskin, 2013), may affect option generation and selection. On the other hand, future research should also investigate how different characteristics of dynamic everyday situations, such as traffic conditions, impact children's option generation and selection. Systematically manipulating environmental constraints across computer-based or real-life tasks will shed light on children's ability to adapt their decision-making strategies in real time. What is learned could inform the development of age-tailored interventions focusing on prevention (e.g., traffic education) and training (e.g., sports, physical education).

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