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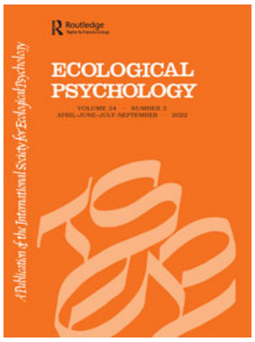

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REPORT

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Height, Size, and/or Gap Width Variation in Jumping Stone Configurations: Which Form of Variation Attracts Children the Most?

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ABSTRACT

Earlier studies revealed that children prefer nonstandardized jumping stone configurations to standardized ones. In the present study, we examined whether children playing on jumping stones prefer variation in stone height, stone size, and/or gap width. In Experiment 1, children could play freely on one standardized configuration and three configurations in which one of the aforementioned factors was varied. It was found that children judged the variation in height as most fun. Yet, the configuration with gap width variation appeared to be most challenging for the children—most overground steps were made in this configuration. In Experiment 2, we examined whether the attractiveness of the configurations increased when height variation was combined with the other forms of variation. Adding size and/or gap width variation to the variation in height did not contribute to the attractiveness of the configuration. In line with experiment 1, it was found that the configurations with gap width variation were judged as the most challenging for children. The implications of these results are discussed in the context of the literature on play.

Introduction

The abundant inactivity in Western society is considered to be a public health risk (e.g., Hills et al., 2007; Ortega et al., 2008; Parker et al., 2009; World Health Organization, 2018). To counter this inactivity, playgrounds and outdoor equipment *could* be crucial means to naturally invite movement for a wide variety of people (Czalczynska-Podolska, 2014; Hart, 1979; Moore, 1986; Potwarka et al., 2008; Solomon, 2014; Ward Thompson, 2013). However, the design of traditional playgrounds have been criticized severely over the last decades (e.g., Adams et al., 2018; Burke, 2013; Fjørtoft, 2004; Hart, 2002; Jansson, 2010; Nebelong, 2004; Solomon, 2005, 2014; Veitch et al., 2007; Woolley, 2008)—ordinary playgrounds are characterized as boring and not very challenging for the target users. But then how to build an environment that invites movement? Building on previous experiments (Jongeneel et al., 2015; Sporrel et al., 2017a, 2017b),

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the present study aims to further investigate design characteristics that attract children in jumping stone configurations.

These previous studies (Jongeneel et al., 2015; Sporrel et al., 2017a, 2017b) were inspired by a recent point of critique that was leveled against traditional playgrounds: they are generally standardized (e.g., Burke, 2013; Nebelong, 2004; Veitch et al., 2007). Indeed, gaps between monkey bars, jumping stones, ladder rungs or ropes are often equal and nonsystematic variation in gap widths is rare. This omnipresent standardization could be the result of esthetic motives of playground designers – after all, symmetric structures tend to have a higher esthetic appeal than asymmetric structures (e.g., Cárdenas & Harris, 2006; Chen et al., 2011; Huang et al., 2018; Jacobsen & Höfel, 2003). Another, but probably related, explanation lies in the rectangular grids generally used by environmental planners (Olwig, 1990). Such grids form an ideal basis for the design of standardized, symmetrical structures. However, Olwig (1990) suggested that children playing do not care about the apparent esthetic appeal of visual order:

> On a walk through even the most spectacular scenery, most children will show much more interest in a mud puddle they can splash in than in the view. Given such a situation, it is questionable whether the sensibilities cultivated by the landscapist are those most needed by a planner seeking to allow for the special-place preferences of children. Giving priority to the visual qualities of perspective, vista, and prospect in an environment ordered such that it can be comprehended from given viewpoints is not likely to produce the environments rich in sensory stimuli and potentiality for manipulation and activity that appear to be most valued by children. *The visual mess and disorder that drives the average parent, let alone the visually trained architect, to distraction is prized by children*. (p. 52; emphasis added)

Moreover, the landscape architect Nebelong (2004) argued that play becomes simplified within standardized playgrounds, because children have to worry less about their next movement. From the perspective of human movement sciences, standardization of play equipment is also not be preferred. First, several studies suggested that variability of practice is important to facilitate children's learning process (e.g. Chow et al., 2011; Schmidt, 1975; Schmidt & Lee, 2003; Schöllhorn et al., 2010). And obviously, a nonstandardized play installation with a variety of gap widths solicits this variability of practice more than a standardized installation. Second, children vary in their action capabilities. Hence, to design play equipment that *affords* (Gibson, 1979/1986) playing for a variety of children, this variation in action capabilities needs to be taken into account. Arguably, a nonstandardized piece of equipment does a better job in doing so than a standardized one.

In keeping with the above considerations, Jongeneel et al. (2015) examined what jumping stone configuration children create themselves if they are the architect of their own playscape. Their choice for using jumping stones as a paradigm was inspired by the Dutch architect Aldo van Eyck who frequently included jumping stones in his landmark playgrounds (Lefaivre & Tzonis, 1999; Solomon, 2005; Withagen & Caljouw, 2017). Yet, although jumping stones could be arranged in an infinite number of ways, van Eyck often placed them in a neat figure-eight pattern, creating only two different gap widths to cross, at least for children with fitting action capabilities (Withagen & Caljouw, 2017). Nevertheless, and in line with Olwig's (1990) observation, Jongeneel et al. (2015) found that children generally positioned the stones in an asymmetric, nonstandardized way with a variety of gap widths. In addition, and in accordance with an

Figure 1. The stepping stone configurations used in the study of Sporrel et al. (2017a). Reprinted with permission.

affordance perspective (e.g., Gibson, 1979/1986; Warren, 1984), Jongeneel et al. (2015) observed that children scaled the gap widths to their estimated stepping capabilities. However, in their study, Jongeneel et al. (2015) could not exclude the possibility that children were incapable of designing standardized, symmetrical configurations. Therefore, they did not have conclusive evidence that children prefer variation to standardization.

In a subsequent study, Sporrel et al. (2017a) therefore tested the children's preferences when they could choose between a symmetrical configuration (resembling Van Eyck's standardized configuration) and one with a variety of stone heights, stone sizes, and gap widths (see Figure 1). They found that children indeed rated the nonstandardized configuration as more fun and slightly more beautiful than the standardized one (Sporrel et al., 2017a). Moreover, the children spent significantly more time playing in the former than in the later. Together with the study of Jongeneel et al. (2015), these results suggest that the omnipresent standardization in playground designs is a misguided principle.

The present study aims to further investigate the children's preference for variation in jumping stone configurations. More precisely, it addresses the question of whether children prefer variation in stone height, stone size, or gap width. In the first experiment, we examined which of these three factors attracted children the most. Similar to the study by Sporrel et al. (2017a), we measured children's play behavior on (each of) the configurations (e.g. number of play bouts, playtime, and number of crossed gaps), and how they judged each configuration on the dimensions of fun and esthetic appeal. To examine whether challenge adds to the attractiveness of a configuration (as suggested by Little & Eager, 2010; Morrongiello, 2004; Sandseter, 2009; Wakes & Beukes, 2012), we additionally asked them to judge the experienced challenge in each of the configurations. The second experiment aimed to examine if the attractiveness of the configurations increases even more when the most preferred form of variation (as found

Table 1. The anthropometrics and maximum jumping distance (means and standard deviations) of the children participating in Experiment 1 (N = 28).

Gender	Age (years)	Leg length (cm)	Max. jumping distance (cm)
15F / 13 M	8.54 ± 1.88	68.23 ± 8.83	152.29 ± 16.36

in the first experiment) was combined with the other form(s), measuring the same variables as in Experiment 1.

Experiment 1

Method

Participants

Thirty-three children (5-12 years old), all attending the same elementary school in the Netherlands, participated in Experiment 1. However, five children were excluded from the data analysis because the anti-slip tape on the stones came off during their playing. Description of the twenty-eight remaining participants can be found in Table 1. The study was approved by the Institutional Ethics Board and both parents and/or guardians gave informed consent for the children's participation.

Configurations

We created four configurations: one standardized configuration and three configurations in which one factor (stone size, stone height, or gap width) was varied (see Figure 2). The four configurations were placed in a square around one small center stone (Ø = 35 cm; height = 3 cm). In the 'standard' configuration, three stones (Ø = 55 cm; height = 3 cm) were positioned in an equilateral triangle with gap widths of 60 cm. This gap width was chosen because earlier research, using children of a similar age, found that this gap width was easily crossable (Sporrel et al., 2017b). In the nonstandard configurations either stone size, stone height, or gap width was varied by changing the outer stone. In the 'gap width' configuration, the outer stone was moved further away from the other two stones to create a configuration with two gap widths of 90 cm, and keeping the other gap width at 60 cm. Again, this distance of 90 cm was based on the study of Sporrel et al. (2017b)—it was the smallest maximum jumping distance measured among their participating children. Furthermore, in the 'size' configuration, the diameter of one stone was decreased to 35 cm, while keeping each of the gap widths at 60 cm. This diameter allowed children to land on the stone with both feet after a jump. In the 'height' configuration, the height of the outer stone was increased to 12 cm. This height was high enough to "stand out", but still jump or step-on-able for our target group.

Procedure

During school time children were assisted (one at a time) to the four configurations placed on a lawn in the schoolyard. First, children were asked to stand on the center stone while facing one of the four configurations. Facing direction was randomized among children. The children were then told that they could play in all the

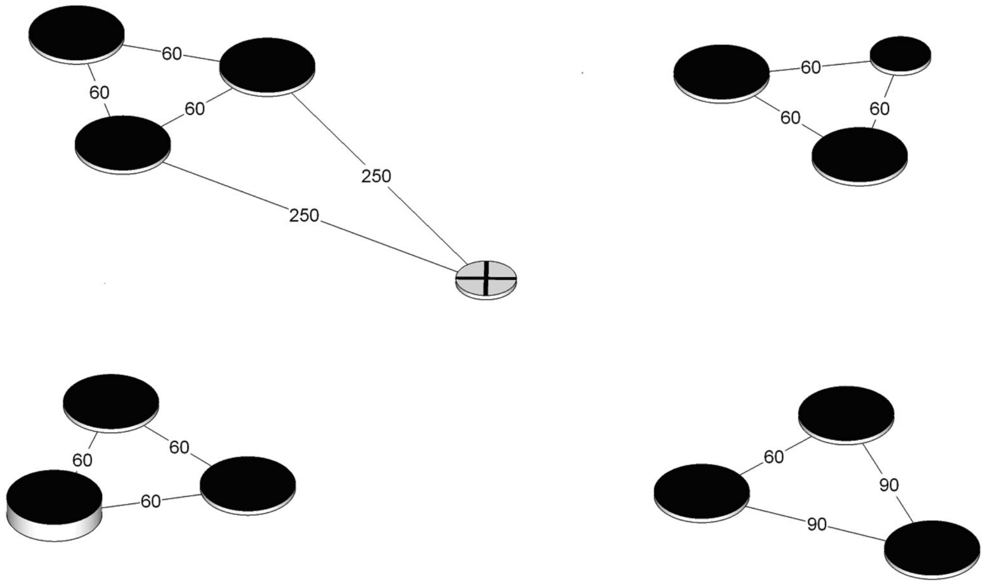

Figure 2. Arrangement of the jumping stone configurations in Experiment 1: the middle stone (Ø = 35 cm, height = 3 cm) and, clockwise from the upper left, the 'standard' configuration (Ø = 55 cm, height = 3 cm), 'size' configuration (Ø = 35 and 55 cm, height = 3 cm), 'gap width' configuration (Ø = 55 cm, height = 3 cm) and 'height' configuration (Ø = 55 cm, height = 3 and 12 cm). All numbers represent gap widths in cm. The gap width between the middle stone and each of the configurations was 250 cm, as shown for the 'standard' configuration.

configurations as they liked (see also Sporrel et al., 2017a). During play time, the investigator(s) distanced themselves from the play site, but remained in sight. Play behavior was recorded with two video cameras (GoPro Hero4 Silver).

After five minutes of playing in the configurations, children were asked to rank the configurations on fun, esthetic appeal, and challenge. For example, in the case of the judgments on fun, the investigator asked in Dutch three questions consecutively: "Which group of stones did you think was the most fun?", "Which group of stones did you think was the least fun?", "From the remaining groups of stones, which group did you think was the most fun?". The rank scores on esthetic appeal and challenge were collected in a similar way, asking which configuration was most/least beautiful and challenging. The order in which the configurations were to be judged on fun, esthetic appeal and challenge, was randomized for each child to control for order effects.

To ensure that all children were able to cross the gap widths of 90 cm, their maximum jumping distance was determined after the playing phase (see Table 1). To measure the maximum jumping distance, children had to stand behind a line with their feet next to each other, and then jump with their dominant leg as far as possible (see also Sporrel et al., 2017a). Children were allowed to take one step after landing, but the distance between the line and the heel of the foot closest to the line was taken as the child's jumping distance. The jump was first explained and demonstrated by the investigator, after which the children were to jump three times as far as possible. The longest jump of which was noted as a child's maximum jumping distance.

Last, leg length was measured either before or after playing in the configurations, depending on which order was most time-efficient. To calculate leg length, a child's sitting height was subtracted from her standing height (Warren, 1984; see also Jongeneel et al., 2015).

Video analysis

Video recordings were analyzed, using VideoLAN Client (VLC) Media Player (version 3.0.11). We assessed the time that children played in each configuration and determined which gaps were crossed. Playtime was defined as the time a child touched one of the stones within a configuration until the moment she stepped off a stone in that configuration in order to move to another configuration (see also Sporrel et al., 2017a). Occasionally, children made one or two extra steps on the ground to go from one stone to another within a configuration. This was still scored as a gap crossing. However, when a child walked more than two steps overground, it was concluded that she temporarily stopped playing in the configuration.

Statistical data analysis

Nonparametric tests were performed because most variables were either ordinal or the data were not normally distributed. Friedman's test was used to determine the effect of a configuration design on children's subjective judgements, number of play bouts, playtime, number of gap crossings and number of gap crossings per time unit. In case significant differences were found, post hoc tests as described by Siegel and Castellan (1988) were conducted.

Results and discussion

Judgements on fun, esthetic appeal, and challenge

Figure 3 presents the medians and interquartile ranges of the rank scores on the judgements of fun, esthetic appeal, and challenge for each of the configurations. A lower score represents a higher rank in fun, esthetic appeal, and challenge. We found significant differences between the configurations in the judgements of fun ($\chi^2(3) = 34.93$, $p < .001$, Kendall's $W = .42$), esthetic appeal ($\chi^2(3) = 11.61$, $p = .009$, Kendall's $W = .14$) and challenge ($\chi^2(3) = 11.70$, $p = .008$, Kendall's $W = .140$). As one can see in Figure 3, post hoc tests revealed that the configuration with variation in height was ranked as more fun than all the other configurations (*ps* $< .01$). The 'height' configuration was ranked as more esthetically appealing than the 'standard' and 'gap width' configuration (*ps* $<.05$). With regard to challenge, children judged the 'gap width' configuration as more challenging than the 'standard' configuration ($p < .01$).

General play behavior

Casual observations of the video recordings revealed that many children visited the configurations one by one in a fixed sequence, as if it was a circuit, with limited time in each configuration (see Figure 4). In line with this observation, we found that the number of play bouts in a configuration—the number of times a child visited a

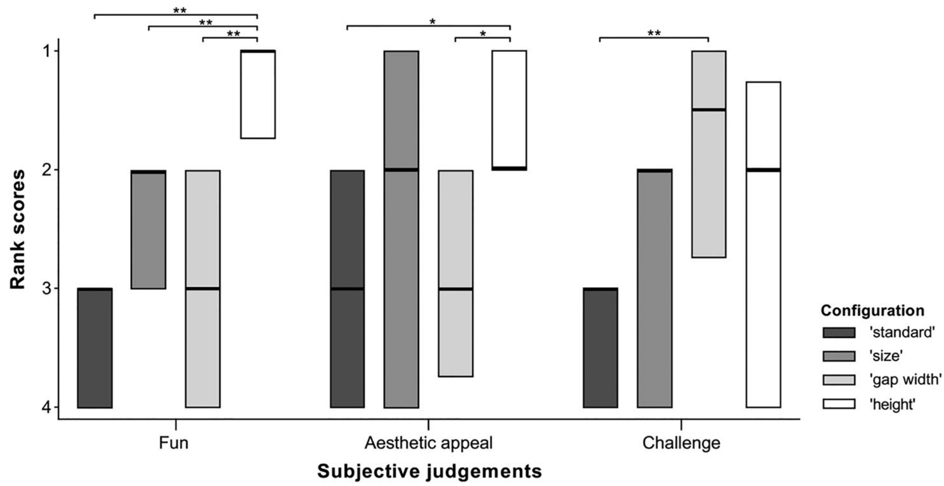

Figure 3. The medians (bold line) and interquartile ranges (25-75th percentile) of the judgment rank scores of the configurations in Experiment 1. The scores 1, 2, 3 and 4 represent respectively the most, second, third and least fun/esthetic appealing/challenging configuration. * and ** indicate significant differences at $p < .05$ and $p < .01$, respectively.

configuration ('standard': Mdn = 15.00, IQR = 9.00–20.00; 'size': Mdn = 14.00, IQR = 8.25–20.00; 'gap width': Mdn = 15.00, IQR = 7.00–20.75; 'height': Mdn = 15.50, IQR = 9.00–21.50)—was not significantly affected by the configuration's design ($\chi^2(3) = 3.39$, $p = .335$, Kendall's $W = .04$).

However, despite the general exploring pattern, the total playtime in each configuration was found to be different ($\chi^2(3) = 19.61$, $p < .001$, Kendall's $W = .23$). Post-hoc tests indicated that children spent significantly more time playing in the 'height' and 'gap width' configuration than in the 'size' configuration ($ps < .01$; see Figure 5).

Yet, this does not necessarily entail that children also crossed more gaps in the 'height' and gap width' configuration compared to the 'size' configuration. Playtime depends on multiple factors, including but not limited to the total number of gaps crossed in each configuration, the time a child observed her surroundings, and the action preparation time needed to cross the different gaps. Hence, the total number of gap crossings in each configuration and the number of gap crossings per minute in each configuration were examined. First, significant differences were found between the total number of gap crossings in each configuration ($\chi^2(3) = 11.52$, $p = .009$, Kendall's $W = .14$). Post hoc tests revealed that in total more gap crossings were made in the 'standard' configuration than in the 'size' configuration ($p < .01$; see Figure 6). Second, to investigate how many crossings were made per time unit in each configuration, we divided the number of gap crossings by the playtime in each configuration. We found that the number of crossed gaps per time unit differed between configurations ($\chi^2(3) = 28.42$, $p < .001$, Kendall's $W = .36$. Compared to the 'gap width' configuration, significant more gaps were crossed per time unit in the 'standard' and 'size' configurations ($ps < .001$; see Figure 6). In addition, significantly more gaps per time unit were crossed in the 'standard' configuration compared to the 'height' configuration ($p < .05$; see Figure 6).

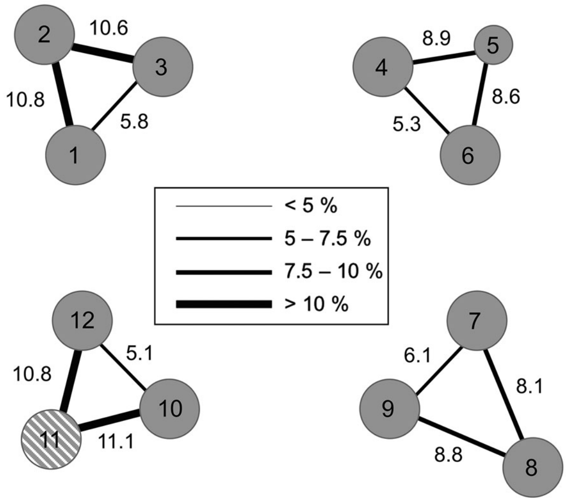

Figure 4. The number of crossings of each gap as a percentage of the total number of gap crossings in Experiment 1 (number of times a specific gap was crossed/ total number of gap crossings * 100)[1]. Clockwise from the upper left, the 'standard' configuration, 'size' configuration, 'gap width' configuration, and 'height' configuration (hatched circle represents the higher stone). The thicker the line of the gap, the more frequently the gap was crossed.

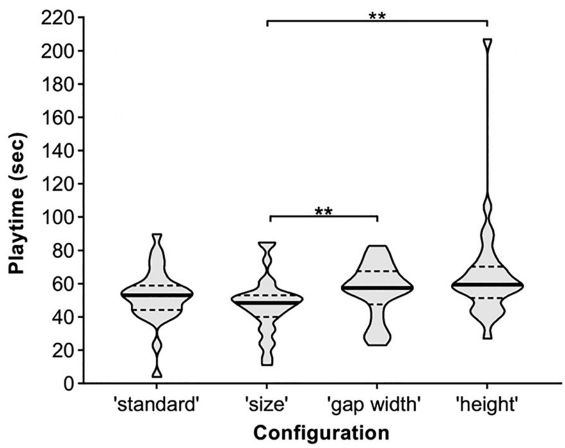

Figure 5. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of children's playtime in each configuration of Experiment 1. ** indicates a significant difference at p <.01.

Last, when solely analyzing the number of gaps that were crossed using one or two overground steps ('standard': Mdn = 1.50, IQR = 0.00–3.00; 'size': Mdn = 1.50, IQR = 0.00–2.00; 'gap width': Mdn = 4.00, IQR = 1.25–9.50; 'height': Mdn = 1.00, IQR = 0.00–2.00), a difference was found between the configurations ($\chi^2(3) = 25.63$, $p < .001$, Kendall's $W = .31$). Post hoc tests revealed that more gaps were crossed with

[1]Six children occasionally crossed two gaps at once (frequency (N = 6): Mdn = 5.5; IQR = 2.0 – 8.8). Such a crossing was executed by a two-leg-jump from one stone while each leg landed on one of the other two stones and/or vice versa. These crossings were counted as two individual gap crossings in Figure 4, but as one crossing in the analysis of the general play behavior.

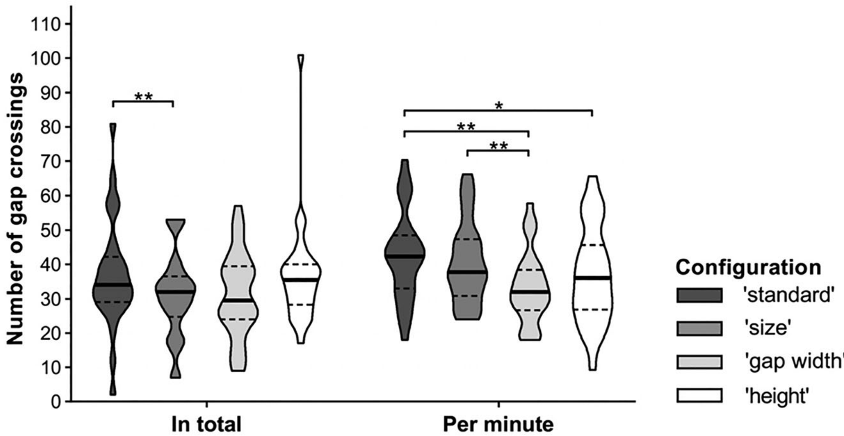

Figure 6. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the total number of gap crossings in each configuration and the number of gap crossings per minute in each configuration of the children in Experiment 1. * and ** indicate significant differences at respectively p <.05 and p <.01.

overground steps in the 'gap width' configuration compared to the other configurations (*ps* < .01).

Taken together, the results of Experiment 1 indicate that children were most attracted to the jumping stone configuration with variation in height—children ranked this configuration as significantly more fun than the other configurations, and also as more esthetically appealing than the 'standard' and 'gap width' configuration. In addition, children's playtime was on average the highest in the 'height' configuration, but only significantly higher than their playtime in the 'size' configuration. However, it might be that the attractiveness of a configuration increases even more when we combine variation in height with size and/or gap width variation. Experiment 2 was designed to provide insight into this matter.

Experiment 2

Method

Participants

A new group of thirty-two children (6-12 years old), attending the same elementary school as the children in Experiment 1, participated in Experiment 2. However, five children were excluded from the analyses—one child was not capable of crossing the 90 cm gap width by means of jumping; one measurement was cut short due to heavy rainfall; and during the measurement of three children a stone was moved out of place. Description of the twenty-seven remaining participants can be found in Table 2.

Configurations

Figure 7 shows the four configurations used in Experiment 2. One of the configurations was identical to the 'height' configuration in Experiment 1 (H). In the three other

Table 2. The anthropometrics and maximum jumping distance (means and standard deviations) of the children participating in Experiment 2 (N = 27).

Gender	Age (years)	Leg length (cm)	Max. jumping distance (cm)
13F / 14 M	8.44 ± 1.83	68.19 ± 8.80	137.69 ± 29.30

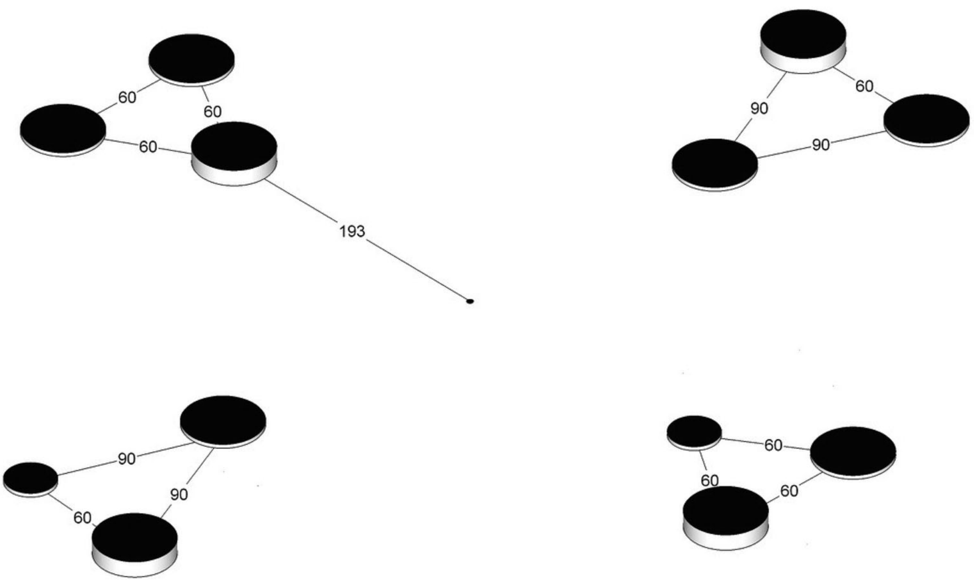

Figure 7. Arrangement of the jumping stone configurations in Experiment 2: clockwise from the upper left, the H configuration (Ø = 55 cm, height = 3 and 12 cm), H-GW configuration (Ø = 55 cm, height = 3 and 12 cm), H-S configuration (Ø = 35 and 55 cm, height = 3 and 12 cm) and H-GW-S configuration (Ø = 35 and 55 cm, height = 3 and 12 cm). All numbers represent gap widths in cm. The gap width between the middle and each of the configurations was 193 cm (as shown for the H configuration).

configurations, height was varied in combination with either a gap width variation (H-GW), stone size variation (H-S), or gap width and stone size variation (H-GW-S). Furthermore, the triangular configurations in Experiment 2 were now pointed inwards, to see if that would break the one by one exploration pattern observed in Experiment 1. To keep similar distances between the four configurations, we created the 90 cm gap widths by moving the outer stones away from the center as shown in Figure 7. Which of the three stones in a configuration were to be the higher and smaller stones was based on a random selection. After rearranging the stones within the available space on the playfield, the middle stone needed to be replaced by a simple dot. Otherwise, some children might have been able to jump from the configurations to the middle stone, and thereby include the middle stone to these configurations.

Procedure, video analysis and statistical data analysis

The procedure, video analysis and statistical data analysis in Experiment 2 were identical to those in Experiment 1.

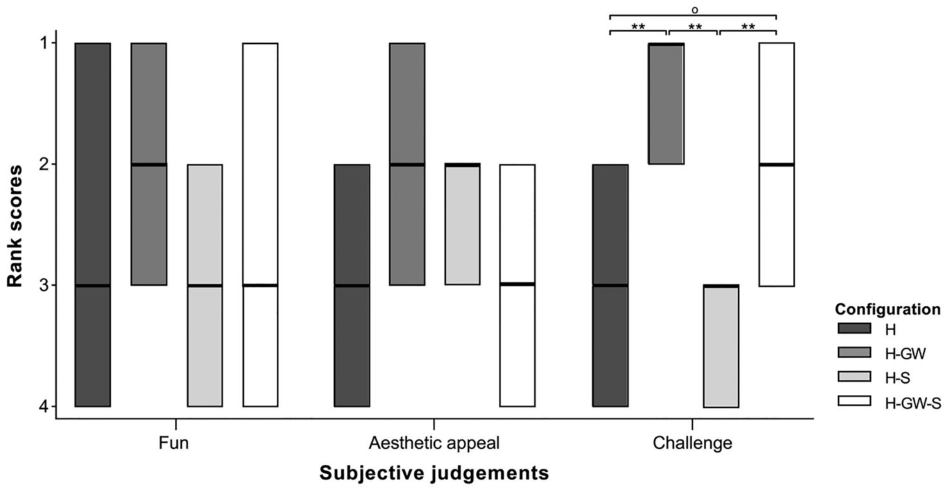

Figure 8. The medians (bold line) and interquartile ranges (25-75th percentile) of the judgment rank scores of the configurations in Experiment 2. The scores 1, 2, 3 and 4 represent respectively the most, second, third and least fun/esthetic appealing/challenging configuration. **, and ° respectively indicate (marginally) significant differences at p <.01, and p =.068.

Results and discussion

Judgements on fun, esthetic appeal, and challenge

For each configuration, the medians and interquartile ranges of the rank scores on judgements of fun, esthetic appeal, and challenge are presented in Figure 8. We found no significant differences between the configurations in the judgments of fun ($\chi^2(3) = 2.87$, $p = .413$, Kendall's $W = .04$) and esthetic appeal ($\chi^2(3) = 2.24$, $p = .523$, Kendall's $W = .03$). We did find significant differences in the judgements of challenge ($\chi^2(3) = 27.93$, $p < .001$, Kendall's $W = .34$). Similar to Experiment 1, configurations including gap width variation (H-GW and H-GW-S) were ranked as more challenging than the other configurations (*ps* $< .01$, although the difference between H-GW-S and H was only marginally significant with $p = .068$).

General play behavior

Although the orientation of the configurations was different from that used in Experiment 1, children still seemed to explore the configurations in a fixed sequence (see Figure 9). In line with this observation, we found that the number of play bouts (H: Mdn = 11.00, IQR = 7.00–14.00; H-GW: Mdn = 9.00, IQR = 7.00–13.00; H-S: Mdn = 9.00, IQR = 4.00–13.00; H-GW-S: Mdn = 10.00, IQR = 7.00–13.00) did not significantly differ between the configurations ($\chi^2(3) = 1.14$, $p = .767$, Kendall's $W = .01$).

However, significant differences in the total playtime were found between the four configurations ($\chi^2(3) = 8.52$, $p = .036$, Kendall's $W = .11$). Post hoc tests revealed that playtime was higher in the H-GW-S than in the H-S configuration ($p < .05$; see Figure 10).

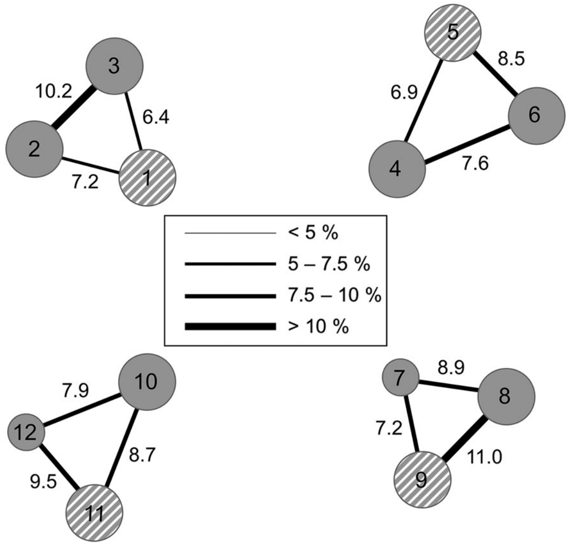

Figure 9. The number of crossings of each gap as a percentage of the total number of gap crossings in Experiment 2 (number of times a specific gap was crossed/ total number of gap crossings * 100)[2]. Clockwise from the upper left, the 'standard' configuration, 'size' configuration, 'gap width' configuration, and 'height' configuration (hatched circle represents the higher stone). The thicker the line of the gap, the more frequently the gap was crossed.

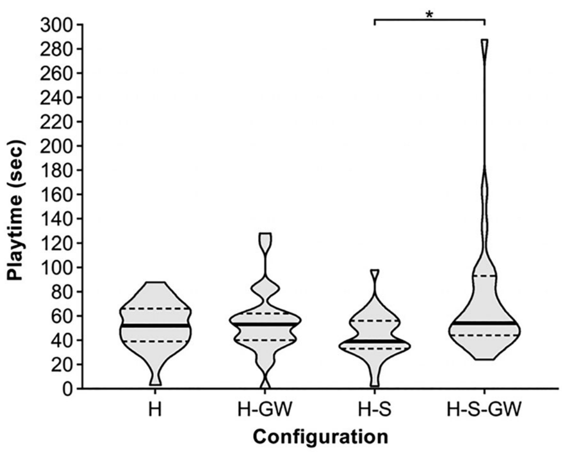

Figure 10. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of children's playtime in each configuration of Experiment 2. * indicates a significant difference at $p < .05$.

Furthermore, we found no significant differences between the configurations in the total number of gaps that children crossed ($\chi^2(3) = 3.71$, $p = .295$, Kendall's $W = .05$; see Figure 11). However, after dividing the total number of gap crossings in each

[2]One child occasionally crossed two gaps at once (13 times). Such a crossing was executed by a two-leg-jump from one stone while each leg landed on one of the other two stones and/or vice versa. These crossings were counted as two individual gap crossings in Figure 9, but as one crossing in the analysis of the general play behavior.

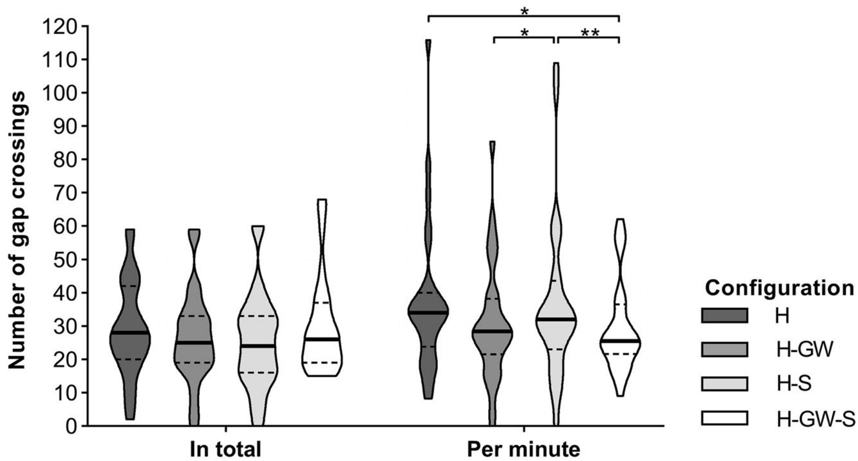

Figure 11. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the total number of gap crossings in each configuration and the number of gap crossings per time unit in each configuration of the children in Experiment 2. * and ** indicate significant differences at respectively p <.05 and p <.01.

configuration by the playtime spent in that configuration, we found, as in Experiment 1, a significant effect of the configuration's design ($\chi^2(3) = 19.22$, $p < .001$, Kendall's $W = .24$). Except for the comparison between H-GW and H ($p = .141$), post hoc tests showed that children crossed less gaps per time unit in the configurations with gap width adjustments compared to the configurations without gap width adjustments (*ps* < .05; see Figure 11).

Furthermore, the number of gaps that were crossed in a configuration using overground steps (H: Mdn = 1.00, IQR = 0.00–2.00; H-GW: Mdn = 3.00, IQR = 1.00–4.00; H-S: Mdn = 0.00, IQR = 0.00–2.00; H-S-GW: Mdn = 2.00, IQR = 1.00–5.00); differed between the configurations ($\chi^2(3) = 29.11$, $p < .001$, Kendall's $W = .36$). In line with Experiment 1, children crossed more gaps with intermediate steps in the configurations with gap width variation (H-GW and H-S-GW) than in the H-S (*ps* < .001) and H configuration (*ps* < .05).

The results of Experiment 2 indicate that children do not prefer height variation combined with other forms of variation to height variation alone. Indeed, we found no significant differences between the configurations in the rankings of fun and esthetic appeal. Taken together, the two experiments suggest that height variation was the driving factor in the degree of attractiveness of our jumping stone configurations.

General discussion

Earlier research showed that when children, young adults, and older adults are the architect of their own jumping stone area, they create nonstandardized configurations with variation in gap widths (Jeschke et al., 2020; Jongeneel et al., 2015). Hence, although contemporary playgrounds and outdoor fitness areas are often standardized, these findings suggest that standardization is a misguided design principle, at least in jumping stone areas. To check this hypothesis among children, Sporrel et al. (2017a) let children play in a standardized jumping stone configuration and a configuration with variation in gap width, stone height and stone size. They found that children indeed judged the nonstandardized configuration as more fun and slightly more beautiful than the standardized configuration. This preference also manifested itself in the time children spent playing in each configuration (Sporrel et al., 2017a). The aim of the present study was to examine what kind of variation within a jumping stone configuration could serve as the most inviting factor for children. In the first experiment, we examined whether children are most attracted to variation in stone size, stone height, or gap width. The second experiment aimed to examine if the attractiveness of the configurations increases even more when the most preferred form of variation was combined with (one or two) of the other forms.

Children prefer height variation

The results of the present study clearly indicated that variation in height attracts children more than variation in stone size or gap width. In Experiment 1, we found that children ranked the height configuration as more fun than any of the other configurations. In addition, children ranked this configuration as more beautiful than the 'standard' and 'gap width' configuration. Further evidence for children's preference for variation in height was found in Experiment 2. Indeed, configurations in which the variation in height was combined with the other forms of variation were not more attractive to the children than the height only configuration. Again, this indicates that height variation is most attractive in jumping stone configurations.

However, one might argue that we should be careful with drawing such a general conclusion about children's preferences based on the present results. After all, using other stone heights, stone sizes and/or gap widths could have led to a different study outcome. For example, perhaps children would have preferred configurations with smaller or even bigger gap widths (or stones with a larger or even smaller diameter) over the present height manipulation. In addition, the present experiment does not equip us to determine whether children preferred the height configuration because of the variation in stone height or because of the height as such[3]. To that end, we should have implemented another configuration with three 12-cm-high stones, and test whether children preferred the configuration with variation in height to this one. However, we can conclude that in the configurations that were included in the present study, the attractiveness had something to do with height.

There are a number of potential explanations for why height had the biggest appeal. For example, the height configuration(s) provided a change of perspective the other configurations did not provide. And children might have appreciated this. Furthermore, stepping up and down require different muscle forces than stepping forward and backward. However, in our view, the most likely explanation for the children's preferences has to do with the risky play that the height afforded. In the literature, it has been suggested that children are attracted to activities that involve the sensations of height and speed (Little & Eager, 2010; Sandseter, 2007; Stephenson, 2003). Of all the

[3]We thank an anonymous reviewer for raising this issue.

configurations included in our study, the ones with the higher stones obviously afforded this 'risky play' the best. Even though our raised stone was only 12 cm high, it was the only stone where misplacement of the feet could lead to an imbalance, which might result in a fall. After all, on the stones with a height of 3 cm, a child's foot was easily supported by the ground when only a small part of the foot was placed on the stone. This type of ground support was absent when stepping onto the highest stone.

Gap width variation was most challenging for children

In the present study we observed that the configurations with variation in gap widths were the most challenging for the children. First, especially in Experiment 2, we observed that the configurations with gap width variation were judged as more challenging than the configurations without this variation. Second, in both experiments, we found the highest number of gaps crossed with overground steps in the configurations that included the larger gap widths of 90 cm, even though all of the analyzed children could cross these larger gaps by means of jumping. Third, generally speaking, children crossed less gaps per time unit in the configurations with the gap width variation compared to the other configurations. This latter finding is in line with a previous study of Sporrel et al. (2017b) who examined children's gap-crossing behavior in jumping stone configurations with and without variation. Among the variables they studied were the action preparation time; that is, the time on a stone before the next crossing behavior was performed. They found that the smaller the estimated maximum jumping distance of a child, the higher her median time was on the stones. In other words, when a gap width was more challenging for a child, she spent more time on a stone before actualizing the cross, which would lead to less gap crossings per time unit. However, recall that in the present study, especially in the configurations with gap width variation, gaps were occasionally crossed with one or two overground steps. This could also be an explanation for why we found that children crossed less gaps per time unit in the configurations with the gap width variation. After all, crossing a gap by means of overground steps consumes more time than direct crossings.

Should we disentangle risky play from challenging play?

As mentioned in Section "Children prefer height variation", earlier authors have suggested that children prefer challenging, risky play (Little & Eager, 2010; Sandseter, 2007, 2009; Stephenson, 2003; Wakes & Beukes, 2012). However, these authors did not provide clear-cut definitions of what risky play and challenging play entails. Yet, challenging play is occasionally opposed to risk free play (e.g., Little & Eager, 2010; Mitchell et al., 2006; Stephenson, 2003). This would indicate that challenging play and risky play boil down to the same thing. Interestingly, the present study questions this presumption. Although our results are in line with the hypothesis that children are attracted to risky behavior (see Section "Children prefer height variation"), they are not in keeping with the hypothesis that children have a preference for challenging play elements. Indeed, children found the configurations with gap width variation the most challenging but not the most attractive (cf. Prieske et al., 2015).

This suggest that disentangling challenge and risk might be important in examining what factors attract children in play. Our initial idea is that challenging play has more to do with whether the to-be-performed action is physically challenging for the person in question, given her action capabilities. Risky play, on the other hand, implies that there are negative consequences when not reaching a goal. For example, jumping from one point on the ground to another might be physically challenging but does not involve high risks. In contrast, crossing a small gap on the top of a deep cliff, might not be physically challenging, but certainly involves risk taking. The present study suggests that children are more attracted to the latter than to the former, but further research is needed to explore the attractiveness of both factors for children playing.

Recommendations for future research in playground

Although we found some significant differences in play time between the configurations in both experiments, we observed that children explored the configurations primarily one by one, as if it was a circuit, with limited time on each configuration. This is in contrast with Sporrel et al. (2017a) who found more pronounced differences in playtime between the configurations they had used. Perhaps, in the configurations of the present study, with only three gaps to cross, children were invited to quickly switch to another configuration. Yet, children clearly indicated that they enjoyed (variation in) height the most. That is, a child's preference for a playground element is not always manifested in her play behavior on this element—children do not necessarily spend most time playing on the element they like best. This indicates that future research on preferences for play elements should not limit itself to an analysis of the actual play behavior but should (additionally) assess the children's subjective judgements.

This brings us to another methodological point worth considering. In the present study we measured the children's preferences by letting them rank the configurations from most fun/beautiful/challenging to least fun/beautiful/challenging. With ranking, subjective judgments are constrained to four categories in our study: most-, second most-, second least- and least- fun/beautiful/challenging. Although we believe that the use of ranking scores was an appropriate means to test which factor of variation attracted children the most, it rendered a detailed analysis of the relationships between each of the variables measured hard, if not impossible. After all, ranking scores depend on each other and are therefore not the most appropriate scores to investigate relations between the variables (e.g., How are fun and esthetic appeal related?). We therefore recommend future studies to examine children's judgements on fun, esthetic appeal, challenge, and risk with Likert scales. This equips one to examine in more detail how the variables measured affect children's preferences.

Conclusion

In conclusion, our study showed that in jumping stone configurations children like variation in height more than variation in stone size and gap width. In addition, the created variation in gap width appeared to be most challenging for our participants. Apparently, the most challenging configuration was not the most preferred configuration in our study.

We hypothesized that children were attracted to the height configurations because of the risk they imply. However, future research is needed to test this hypothesis.

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