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Attractive Stepping Stones Landscapes: Preference for Stone Height Variation Appears to Be Age Independent

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ABSTRACT

An earlier study on the attractiveness of stepping stones configurations revealed that children like variation in stone height better than variation in stone size or gap width. In the present study, we conducted two experiments to examine whether this preference is found also in young and older adults. In Experiment 1, participants stepped freely in a standardized configuration, and three configurations with either height, size or gap width variation. Most interestingly, adults judged playgrounds with variation in stone height as most fun and beautiful, suggesting that the preference for variation in height is indeed age independent. In Experiment 2, we compared the configuration with only height variation with three configurations in which variation in height was combined with variation in stone size or gap width, or both. Although we found no significant differences among the configurations in the older adults, young adults judged the combination of height with size and gap width variation as more fun and esthetically appealing than the configuration with only height variation. The implications of our findings for playground research and designers are discussed.

Introduction

People of all ages prefer variation to standardization in stepping stones landscapes (Jeschke et al., 2020; Jongeneel et al., 2015; Sporrel et al. 2017a). In an earlier study, we examined which form of variation attracted children the most in a stepping stones landscape: height, size, and/or gap width variation (Jeschke et al., 2022). In the present study we extended this analysis to young and older adults. The motivation was to advance the knowledge on creating attractive playground designs to combat a public health concern: the physical inactivity among people of all ages (World Health Organization, 2018). After all, for playgrounds to naturally invite physical activity for people of all ages, we need to know whether the attractive characteristics are age independent or whether each group has their own preferred design.

In our previous study (Jeschke et al., 2022), we let children play in a landscape with one standardized configuration and three configurations with either stone height

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variation, stone size variation, or gap width variation. Although no clear differences were found in children's stepping behavior, we found that children ranked variation in stone height as most fun. In a second experiment, we tested whether a configuration would become even more attractive when we combined height variation with size and/or gap width variation. To that end, children could play in a configuration with only height variation alone and three configurations in which height variation was combined with stone size or gap width variation, or both. No significant differences were found in the fun judgments or step behavior between the configurations. The variation in gap width appeared to be most challenging in both experiments. Based on our results, we suggested that children are perhaps not attracted to the most physically challenging configuration but to the ones that imply a certain risk or an upward movement.

In the present follow-up study, we will investigate which form of variation attracts young and older adults the most in a stepping stones landscape. Is the preference for height variation as seen in children also apparent in young and older adults? To test this, we will replicate the study of Jeschke et al. (2022) with young and older adults as participants. However, we will use smaller gap widths to ensure that all older adults are able to cross the gaps. Moreover, in addition to the judgments on challenge, we will now also measure how risky participants found the configurations. This allows us to determine whether participants are more attracted to certain configurations because of the risk they imply. Last, we will use a 9-point Likert scale instead of ranking scores to measure the subjective judgments, allowing for a more detailed analysis of the relationships between the judgments.

Experiment 1

Method

Participants

All participants had to live independently at home, be able to walk outdoors for at least 15 min without walking aids, and be capable of crossing a 65 cm gap without losing balance. In addition, after the experiment, participants were asked whether they previously had heard from our earlier research studying the stepping stones preferences of children (Jeschke et al., 2020). Four young adults indicated that they did and were excluded from the analyses of Experiment 1 to avoid possible bias. The characteristics of the included 26 young adults (19 - 28 years old) and 25 older adults (61 - 80 years old) are presented in Table 1. The study was approved by the Local ethics Review Board Human Movement Sciences nWMO studies (study number 202100545) and all participants gave their informed consent.

Table 1. The anthropometrics (means and standard deviations) of the 26 young and 25 older adults participating in Experiment 1.

Group	Gender	Age (years)	Leg length (cm)
Young adults	19F / 7M	22.15 ± 2.12	90.31 ± 5.82
Older adults	18F / 7M	70.75 ± 5.40	87.60 ± 5.99

Configurations

The configurations studied in Experiment 1 are presented in Figure 1. In line with Jeschke et al. (2022), we created one standardized configuration ('standard') and three configurations with variation in either gap width ('gap width'), stone size ('size'), or stone height ('height'). To create the configurations, we used the same stones as Jeschke et al. (2022): the diameter and height of a standard stone was respectively 55 cm and 3 cm. In the 'size' configuration we reduced the diameter of one stone to 35 cm, and in the 'height' configuration we increased the height of one stone to 12 cm. Given that the smallest maximum stepping distance of the older adults in Jeschke et al. (2020) was 65 cm, we changed the 60 cm and 90 cm gap widths used in Jeschke et al. (2022) to respectively 45 cm and 65 cm in the present study. That way, we ensured that all older adults could cross all gaps, while still having two clearly different distances in the configuration with gap width variation. In addition, we placed the stones in an empty classroom instead of on a field of grass to be independent of the Dutch weather. To prevent the stones from slipping on the ground, and the participants from slipping on the stones, anti-slip material was attached to both the bottom and top sides of the stones.

Procedure

Before the start of the experiment, one of the researchers checked if the participant complied with the inclusion criteria (live independently at home, able to walk outdoors for at least 15 min without walking aids, and able to step over a gap of 65 cm without losing balance). The first two criteria were checked by simply asking the participants if they applied to them. For the third criterion, older adults were asked to step over a line that was placed 65 cm in front of their toes to assess if they could cross this distance without losing balance. There was a graspable windowsill on the left side of the participant and an experimenter standing on the right side of the participant, to minimize the risk of falling when the participants failed to keep their balance while making the step.

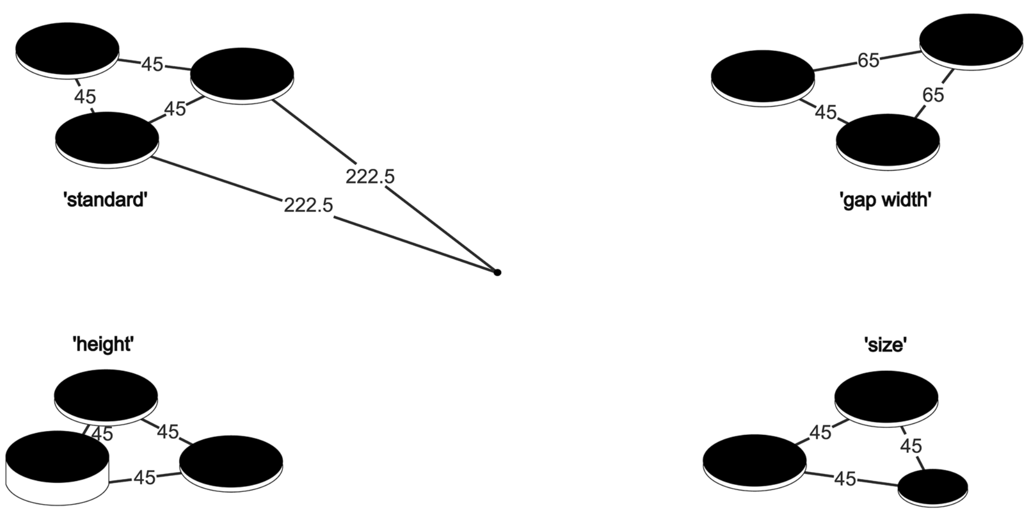

Figure 1. Arrangement of the jumping stone configurations in Experiment 1. All numbers represent gap widths in cm. The gap widths between the middle of the landscape and each of the configurations was 222.5 cm (as shown for the 'standard' configuration).

The study was divided into four parts. First, we measured the anthropometrics of the participants. Leg length was calculated by subtracting the sitting height from the standing height, as suggested by Warren (1984). To determine the sitting height, we let participants sit in a chair and measured the length between the seat of the chair and the top of the participant's head.

Second, the participants were instructed to stand on a white cross in the middle of the four configurations while facing one of the configurations. Facing direction was randomized across all participants. Participants were then asked to step in the stepping stones landscape as they liked for a duration of three minutes. During these three minutes, the experimenter(s) distanced themselves from the landscape—the participants were to not engage socially with them in any way. Stepping behavior was recorded with two video cameras (GoPro Hero4 Silver), placed on two opposite sides of the landscape.

After the stepping phase was completed, the participant was again instructed to take position in the middle of all configurations. At that spot, the participant was to rate each configuration on fun, esthetic appeal, challenge, and risk. To that end, we used a 9-point Likert scale. The order of the questions and the order in which the configurations were to be judged were randomized for each participant.

Last, we measured the participant's action capacities. We conducted the timed "Up & Go" (TUG) test and measured participant's maximum stepping distance. As described by Podsiadlo and Richardson (1991), we measured the time it took a participant to "stand up from a standard arm chair (approximate seat height of 46 cm), walk a distance of 3 meters, turn, walk back to the chair, and sit down again" (p. 143). To become familiar with the test, participants executed the test once before being timed. To determine the maximum stepping distance, participants had to stand with both feet next to each other behind a line on an anti-slip mat, then step with their dominant leg as far as possible, and place the trailing foot next to the leading foot. If the participants jumped or lost their balance, the step was redone. After three successful steps, the longest step was noted as the participant's maximum step distance.

Video analysis

Video recordings were analyzed, using VideoLAN Client (VLC) Media Player (version 3.0.11). We analyzed the playtime, the number of gap crossings with and without on-ground steps, and the number of play bouts in each configuration. Playtime in a configuration was defined as the duration of a play bout within this specific configuration. A play bout started at the moment that the participants stepped on one of the stones in a specific configuration and ended when they stepped off of the stones in order to move to another configuration or to take three or more steps on the ground before returning to the same configuration. If a participant used one or two steps on the ground to move between two stones of the same configuration, this was scored as a gap crossing within that configuration. However, when three or more steps on the ground were used to step to the next stone this was no longer registered as playtime or a play bout within that configuration.

Statistical data analysis

Most variables were ordinal or not normally distributed. Therefore, Friedman's tests were used to test for the effect of each configuration on the subjective judgments,

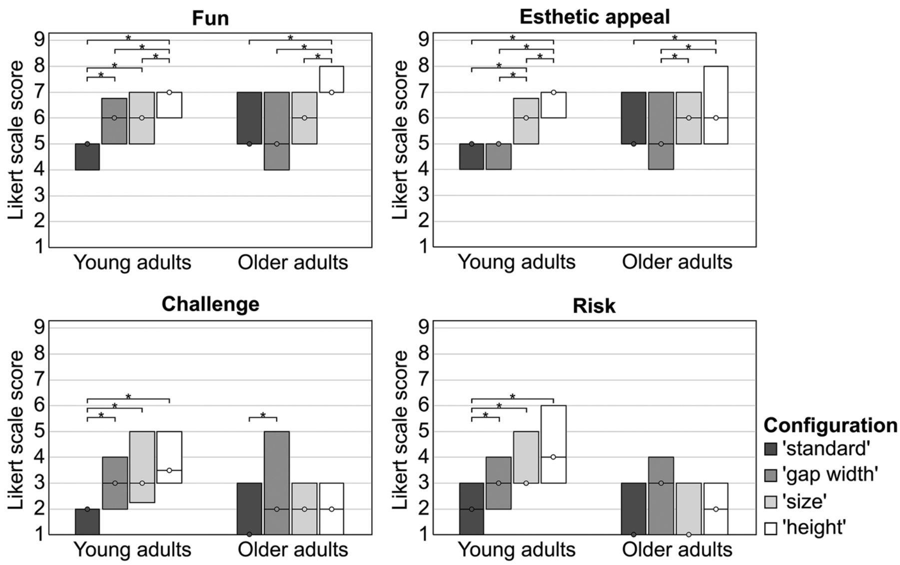

Figure 2. The medians (dots) and interquartile ranges (25-75th percentile) of the judgment scores of the configurations in Experiment 1. The higher the scores, the more fun, esthetically appealing, challenging and risky a configuration was judged. * indicates a significant difference at $p < .05$.

number of play bouts, playtime, number of gap crossings, and number of gap crossings per time unit. When Friedman test revealed significant differences between configurations, we used the Conover post-hoc test with Bonferroni correction (Conover, 1999) to examine which configurations differed from each other[1]. To compare the action capabilities and judgment scores between young and older adults, we respectively used the independent *t*-test and the Mann-Whitney-U test.

Results and discussion

Judgments on fun, esthetic appeal, challenge, and risk

The medians and interquartile ranges of the subjective judgments scores for the configuration of Experiment 1 are presented in Figure 2. We found significant differences among the configurations in fun and esthetic appeal scores for both young (fun:$\chi^2(3) = 43.84$, $p < .001$, Kendall's $W = .56$; esthetic appeal: $\chi^2(3) = 46.64$, $p < .001$, Kendall's $W = .60$) and older adults (fun: $\chi^2(3) = 35.77$, $p < .001$, Kendall's $W = .48$, esthetic appeal: $\chi^2(3) = 24.30$, $p < .001$, Kendall's $W = .32$). The post hoc test results are presented in Figure 2. Most interestingly, both young and older adults rated the configuration with height variation as more fun than all the other configurations and as more beautiful than almost all other configurations. This is in line with children's judgments in the study of Jeschke et al. (2022).

[1]In Jeschke et al. (2022), we used the Bonferroni-Dunn test (Siegel and Castellan, 1988) to detect the post-hoc differences. However, since the current data has more tied values, the Bonferroni-Dunn test was too conservative to detect which configurations differed from each other. Therefore, we chose to use the more powerful Conover post hoc test with Bonferroni correction in the present study.

Furthermore, young adults judged all configurations as more challenging ($\chi^2(3)$ = 36.19, p < .001, Kendall's W = .46) and risky ($\chi^2(3)$ = 26.09, p < .001, Kendall's W = .34) than the 'standard' configuration. Older adults only judged the 'gap width' configuration as more challenging than the 'standard' configuration ($\chi^2(3)$ = 10.49, p = .015; Kendall's W = .14). No significant differences among configurations were found in the older adult's risk scores ($\chi^2(3)$ = 2.80, p = .424, Kendall's W = .04). These findings are partly in line with Jeschke et al. (2022), where children rated the 'gap width' configuration as more challenging than the 'standard' configuration.

An additional noteworthy observation relating to the judgments of challenge and risk is that compared to young adults, older adults seemed to generally judge the configurations as less challenging and risky than young adults (see Figure 2). To check this, we summed for each participant the judgment scores they gave to the four configurations on challenge (Mdn_{young} = 12, IQR_{young}= 9.75 − 15.5; Mdn_{older} = 7, IQR_{older}= 4.5 − 13) and risk (Mdn_{young} = 13, IQR_{young} = 10 − 16.25; Mdn_{older} = 10, IQR_{older} = 4 − 13). Indeed, Mann-Whitney-U test on the sum of scores on challenge (U = 189.50, z = −2.56, p = .010) and risk (U = 190.50, z = −2.55, p = .011) confirmed that older adults rated the configurations as less challenging and risky than young adults did. When looking at the outcomes of the TUG test and the maximal stepping test, we did not expect to find this difference. Table 2 presents the means and standard deviations of the TUG test score and maximum stepping distances of both groups. Independent sample t-test revealed that, compared to young adults, older adults were slower during the TUG test ($t(38.54)$ = 3.25, p = .001, d = 1.12) and made smaller steps during the maximum step test ($t(49)$ = 5.46, p < .001, d = 12.11). Thus, contrary to what the subjective judgments suggest, we expected the configurations to be overall more physically challenging for the older adults than for the younger adults.

Last, we aimed to investigate the relations between judgments of fun, esthetic appeal, challenge and risk in Experiment 1. Table 3 shows the Kendall's tau correlation matrix between the subjective judgments for each configuration and age group. Especially for the older adults, we found significant correlations between judgments of fun and esthetic appeal and between judgments of challenge and risk. For the younger adults, we found these correlations to be (marginally) significant for three of the four configurations and we found an additional significant relation between esthetic appeal and risk in the 'height' configuration. Taken together, these correlations suggest that experiences or fun and beauty were related, and so were the experiences of challenge and risk.

General play behavior

To check if the most attractive configuration ('height') was also visited the most, we analyzed the number of play bouts in each configuration (see Figure 3). In line

Table 2. The means and standard deviations of the maximum jumping distance and TUG scores of the 26 young and 25 older adults participating in Experiment 1.

Group	Max. stepping distance (cm)	TUG test (s)
Young adults	116.85 ± 12.91	7.26 ± 0.80
Older adults	98.32 ± 11.22	8.28 ± 1.37

Table 3. Kendall's tau correlation matrix of the subjective judgments for each configuration and age group in Experiment 1.

		Young adults			Older adults		
Config.	Subj. Judgm.	1.	2.	3.	1.	2.	3.
'standard'	1. Fun						
	2. Esthet. appeal	**.482****			**.679****		
	3. Challenge	−.112	−.145		.005	.064	
	4. Risk	−.017	−.077	.018	.114	.028	**.583****
'gap width'	1. Fun						
	2. Esthet. appeal	**.322**[a]			**.603****		
	3. Challenge	.088	.267		−.227	−.238	
	4. Risk	.307	.185	**.355***	−.090	.055	**.528****
'size'	1. Fun						
	2. Esthet. appeal	.214			**.480****		
	3. Challenge	.083	−.200		−.168	−.121	
	4. Risk	−.152	.012	**.415****	.023	.112	**.673****
'height'	1. Fun						
	2. Esthet. appeal	**.339***			**.450****		
	3. Challenge	.248	.202		−.078	−.199	
	4. Risk	.181	**.385***	**.433****	.055	.156	**.502****

* and ** indicate significant correlations at respectively at $p < .05$ and $p < .01$. [a] indicates a marginally significant correlation at $p = .052$.

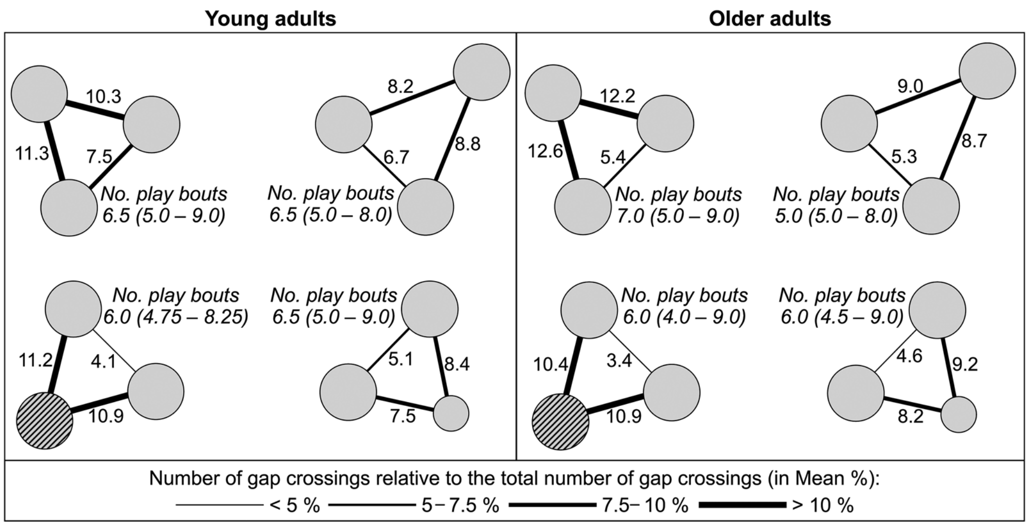

Figure 3. For both young and older adults clockwise from the upper left: the 'standard' configuration, 'size' configuration, 'gap width' configuration, and 'height' configuration (hatched circle represents the higher stone). Next to each gap we present the average number of crossings as a percentage of the total number of gap crossings (number of times the gap was crossed/ total number of gap crossings * 100)[2]. The thicker the line of the gap, the more frequently the gap was crossed. In addition, the medians and interquartile ranges of the number of play bouts are presented for each configuration.

[2]Three young adults and one older adult occasionally crossed two gaps at once (respectively 2, 6, 1 and 7 times). These crossing were counted as two individual gap crossings in Figure 3, but as one crossing in the analysis of the general play behavior.

with Jeschke et al. (2022), we observed that most participants visited the configurations one by one in a fixed sequence, resulting in no significant differences among the configurations in the number of play bouts (young adults: $\chi^2(3) = 2.47$, $p = .482$, Kendall's $W = .03$; older adults: $\chi^2(3) = 5.03$, $p = .169$, Kendall's $W = .07$; see Figure 3). Jeschke et al. (2022) suggested that children were perhaps invited to frequently switch between the studied configurations, because there were only three gaps to cross. The present results indicate that this might be the case for adults as well.

In addition, we checked whether our participants spent more playtime in certain configurations than in others. Similar to the children in Jeschke et al. (2022), older adults spent more playtime in the 'gap width' and 'height' configurations than in the 'size' configuration ($\chi^2(3) = 14.56$, $p = .002$; Kendall's $W = .19$; see Figure 4). Among young adults, on the other hand, we did not find differences among the configurations in playtime ($\chi^2(3) = 5.02$, $p = .170$, Kendall's $W = .06$; see Figure 4). One explanation could be that young adults switched between configurations on an even more regular basis than the children and older adults did.

Furthermore, we analyzed the number of gap crossings of both groups in each configuration. We found no differences between configurations in the total number of gaps crossed for both the young adults ($\chi^2(3) = 4.26$, $p = .235$, Kendall's $W = .06$; see Figure 5) and older adults ($\chi^2(3) = 1.82$, $p = .610$, Kendall's $W = .02$; see Figure 5). Although the older adults did not frequently cross gaps with the help of on-ground steps ('standard': Mdn = 0, IQR= 0 − 0.5; 'gap width': Mdn = 0, IQR= 0 – 1.5; 'size': Mdn = 0, IQR= 0 − 0.5; 'height': Mdn = 0, IQR= 0 − 0), the number of times they did significantly differed among configurations ($\chi^2(3) = 10.01$, $p = .018$, Kendall's $W = .13$). Older adults used significantly more often on-ground steps in the 'gap width' configuration than in the 'height' configuration ($p < .05$). This step behavior is similar to the participating children in Jeschke et al. (2022). Young adults seldom crossed gaps with the help of on-ground steps (the medians and interquartile ranges of the number of gaps crossed with on-ground step by young adults were equal to zero for all configurations), and thus no significant differences between the configurations

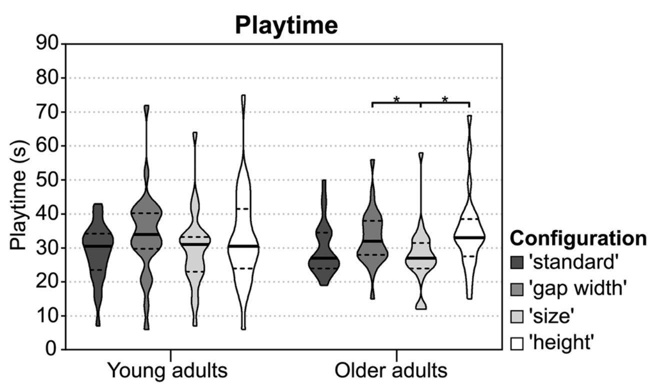

Figure 4. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the playtime spent by young and older adults in each configuration of Experiment 1. * indicates a significant difference at $p < .05$.

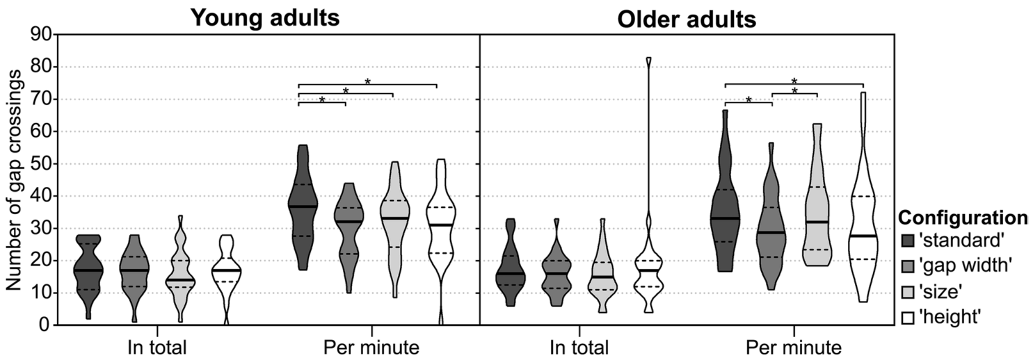

Figure 5. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the total number of gap crossings of young and older adults in each configuration, and the number of gap crossings per minute in each configuration for both groups in Experiment 1. * indicates a significant difference at p < .05.

were found in the number of times they used an on-ground step to cross a gap ($\chi^2(3)$ = 3.18, p = .365, Kendall's W = .04).

Last, we analyzed the number of crossed gaps per minute among both groups (see Figure 5). Note that on average participants did not spend (more than) a minute in a single configuration (see Figure 4), rendering the number of crossings per minute in a configuration higher than the total number of crossings in that configuration (see Figure 5). Slower gap crossing could imply that gaps were more challenging to cross, leading to more time on the stone before the crossing (cf. Sporrel et al., 2017b) and/or more "recovery" time after the landing (e.g. to find balance again). For both groups, we did find significant differences in the number of crossed gaps per time unit (young adults: $\chi^2(3)$ = 23.66, p < .001, Kendall's W = .30; older adults: $\chi^2(3)$ = 23.26, p < .001, Kendall's W = .31). Older adults crossed more gaps per time unit in the 'standard' and 'size' configurations than in the 'gap width' configurations (see Figure 5). Again, this step behavior is similar to that of the earlier measured children (Jeschke et al., 2022). Furthermore, both groups crossed more gaps per time unit in the 'standard' configuration compared to the 'height' configuration (see Figure 5). In addition, young adults crossed more gaps per time unit in the standardized configuration than in all three other configurations. These findings could suggest that gap crossings in the standardized configuration required the least "action preparation" (Sporrel et al., 2017b) and/or "recovery" time. Interestingly, the standardized configuration was indeed rated as the least challenging and risky by the young adults. Both findings are in line with Nebelong's (2004) statement that movements become simplified in a standardized landscape.

In conclusion, although we found no significant differences between configurations for both young and older adults in the number of play bouts or gap crossings, we found that both groups clearly judged the 'height' configuration as most attractive. In Experiment 2, we will test whether the attractiveness of a configuration increases when we combine height variation with variation in size and/or gap width.

Experiment 2

Method

Participants

Following the same inclusion criteria as in Experiment 1, a new group of 25 young adults (18 - 28 years old) and 28 older adults (60 - 85 years old) participated in Experiment 2. Their characteristics can be found in Table 4. None of the participants were excluded from the data analyses. Again, all participants gave their informed consent.

Configurations

For Experiment 2, four new configurations were created with stones identical to the ones used in Experiment 1. As shown in Figure 6, we created one configuration with only height variation (H) and three configurations where height variation was combined with either gap width variation (H-GW), stone size variation (H-S), or both (H-GW-S). This set-up was similar to Experiment 2 in Jeschke et al. (2022), except that we again reduced the gap widths to 45 cm and 65 cm and placed the stones indoors.

Table 4. The anthropometrics (means and standard deviations) of the 25 young and 28 older adults participating in Experiment 2.

Group	Gender	Age (years)	Leg length (cm)
Young adults	14F / 11M	21.52 ± 2.01	90.98 ± 4.82
Older adults	16F / 12M	70.08 ± 5.62	88.38 ± 5.21

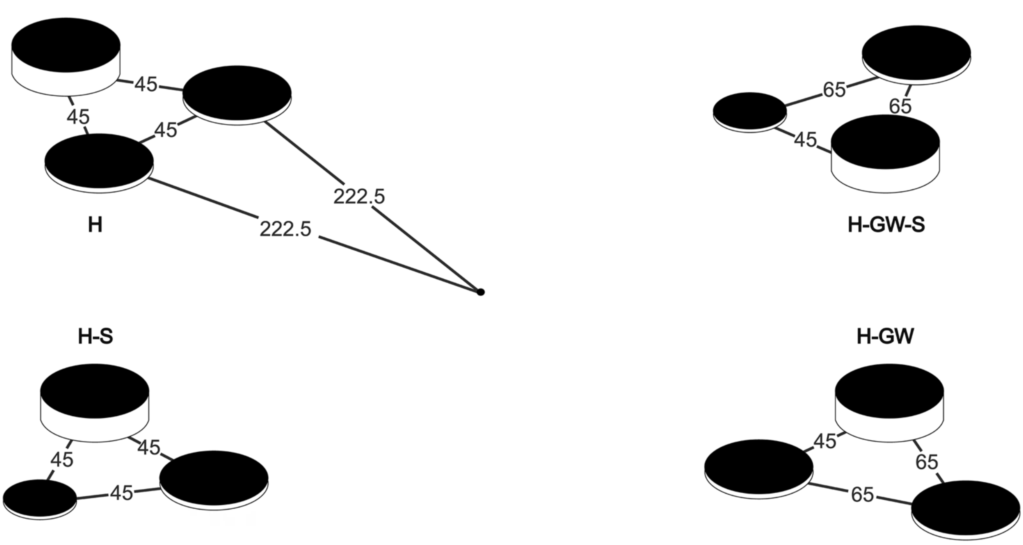

Figure 6. Arrangement of the jumping stone configurations in Experiment 2. All numbers represent gap widths in cm. The gap width between the middle and each of the configurations was 222.5 cm (as shown for the H configuration).

Procedure

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

Results and discussion

Judgments on fun, esthetic appeal, and challenge

Figure 7 presents the medians and interquartile ranges of the subjective judgments scores for each configuration in Experiment 2. For older adults we did not find significant differences among the configurations for both the judgments of fun ($\chi^2(3)$ = 6.88, p = .076, Kendall's W = .08) and esthetic appealing ($\chi^2(3)$ = 2.89, p = .409, Kendall's W = .03). Again, this is similar to the children in the study of Jeschke et al. (2022).

Yet, young adults judged the H-GW-S configuration as more fun than the H and H-GW configurations ($\chi^2(3)$ = 15.79, p = .001, Kendall's W = .21; see Figure 7) and more esthetically appealing than the H configuration ($\chi^2(3)$ = 8.96, p = .030, Kendall's W = .12; see Figure 7). This indicates that, contrary to children and older adults, young adults did find a combination of height, size and gap width variation more attractive than height variation alone.

Furthermore, significant differences were found among configurations in judgments of challenge (young adults: $\chi^2(3)$ = 8.88, p = .031, Kendall's W = .12; older adults: $\chi^2(3)$ = 9.15, p = .027, Kendall's W = .11) and risk (young adults: $\chi^2(3)$ = 14.05,

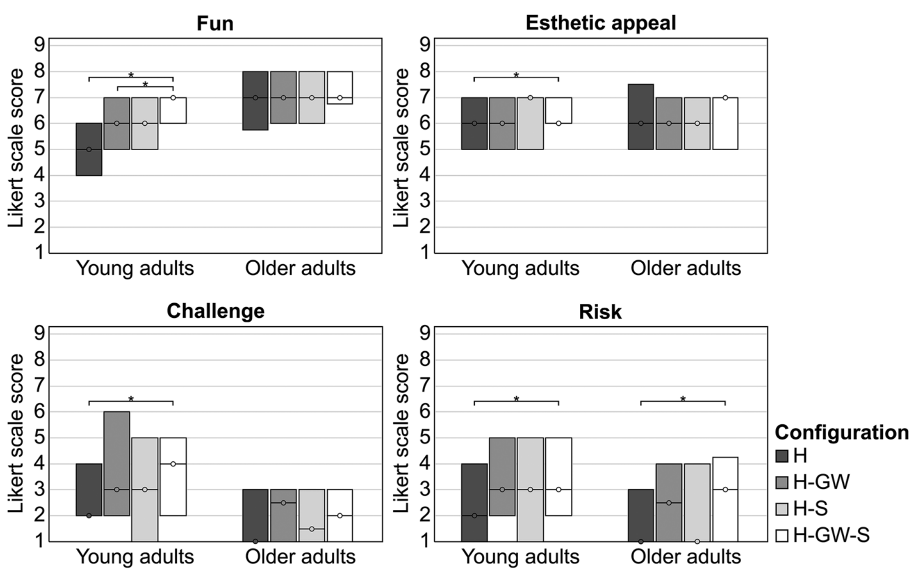

Figure 7. The medians (dots) and interquartile ranges (25-75th percentile) of the judgment scores of the configurations in Experiment 2. The higher the scores, the more fun, esthetic appealing, challenging and risky a configuration was judged. * indicates a significant difference at p < .05.

Table 5. The means and standard deviations of the maximum jumping distance and TUG scores of the 25 young and 28 older adults participating in Experiment 2.

Group	Max. stepping distance (cm)	TUG test (s)
Young adults	117.38 ± 12.17	7.14 ± 0.60
Older adults	94.09 ± 12.86	8.55 ± 1.41

p = .003, Kendall's W = .19; older adults: $\chi^2(3)$ = 12.70, p = .005, Kendall's W = .15). Young adults judged the H-GW-S configuration as more challenging and risky than the H configuration (see Figure 7). Older adults also judged H-GW-S as more risky than the H configuration (see Figure 7). However, although Friedman test revealed that older adults judged the configurations differently on challenge as well, no significant differences were detected in the post-hoc comparisons.

In addition, and in line with Experiment 1, older adults seemed to again generally judge the configurations as less challenging and risky than younger adults (see Figure 7). Mann-Whitney-U tests on the total summed scores of participant's judgments on challenge (Mdn_{young} = 14, IQR_{young}= 8 – 20; Mdn_{older} = 8, IQR_{older}= 4 – 12) and risk (Mdn_{young} = 10, IQR_{young} = 6 – 21; Mdn_{older} = 9, IQR_{older} = 4 – 15.5), showed that older adults indeed rated the configurations as significantly less challenging than young adults (U = 233.00, z = −2.10, p = .036), but this difference was not significant for risk (U = 267.50, z = −1.49, p = .137). Yet, independent sample t-tests revealed that, compared to young adults, older adults were slower during the TUG test ($t(37.27)$ = −4.84, p < .001, d = 1.11; see Table 5) and made smaller steps during the maximum step test ($t(51)$ = 6.75, p < .001, d = 12.54; see Table 5). Thus, because in both experiments older adults showed to have declined action capacities compared to the youngsters, we expected the older adults to judge the configurations as more challenging than the young adults. Yet, the subjective judgments were the other way around—older adults rated the configurations as less challenging and in Experiment 1 also as less risky than the young adults did. We will elaborate on this in the general discussion.

Last, we investigated the relations among judgments of fun, esthetic appeal, challenge and risk. Table 6 shows the Kendall's tau correlation matrix between the subjective judgments for each configuration and age group. For both young and older adults we found significant correlations between judgments of fun and esthetic appeal, and between judgments of challenge and risk in each configuration (although the relation between fun and esthetic appeal was marginally significant in the H-GW configuration for younger adults). This further confirms the relationships between experienced beauty and fun, and between experienced risk and challenge.

General play behavior

As in Experiment 1, we analyzed the number of play bouts in each configuration (Figure 8). Friedman tests indicated significant differences in the number of visits to each configuration for both young adults ($\chi^2(3)$ = 16.12, p = .001, Kendall's W = .22) and older adults ($\chi^2(3)$ = 9.44, p = .024; Kendall's W = .11). Post-hoc tests showed that young adults brought more visits to the H-GW configuration than to the H configuration (p < .01). However, for older adults, the Conover post-hoc test with Bonferroni correction did not detect significant differences.

Table 6. Kendall's tau correlation matrix of the subjective judgments for each configuration and age group in Experiment 2.

		Young adults			Older adults		
Config.	Subj. Judgm.	1.	2.	3.	1.	2.	3.
H-GW-S	1. Fun						
	2. Esthet. appeal	**.375***			**.536****		
	3. Challenge	−.049	−.267		−.038	−.153	
	4. Risk	.107	−.008	**.520****	−.041	−.220	**.677****
H-GW	1. Fun						
	2. Esthet. appeal	**.092**[a]			**.633****		
	3. Challenge	.071	−.056		−.068	.003	
	4. Risk	−.068	−.040	**.549****	−.139	−.096	**.645****
H-S	1. Fun	**.403***			**.389***		
	2. Esthet. appeal	−.062	−.020		−.078	.015	
	3. Challenge	.025	.049	**.602****	.062	−.160	**.615****
	4. Risk						
H	1. Fun						
	2. Esthet. appeal	**.660****			**.466****		
	3. Challenge	.106	.125		−.061	−.164	
	4. Risk	−.044	.024	**.653****	.072	−.217	**.609****

* and ** indicate significant correlations at respectively at $p < .05$ and $p < .01$. [a] Indicates a marginally significant correlation at $p = .058$.

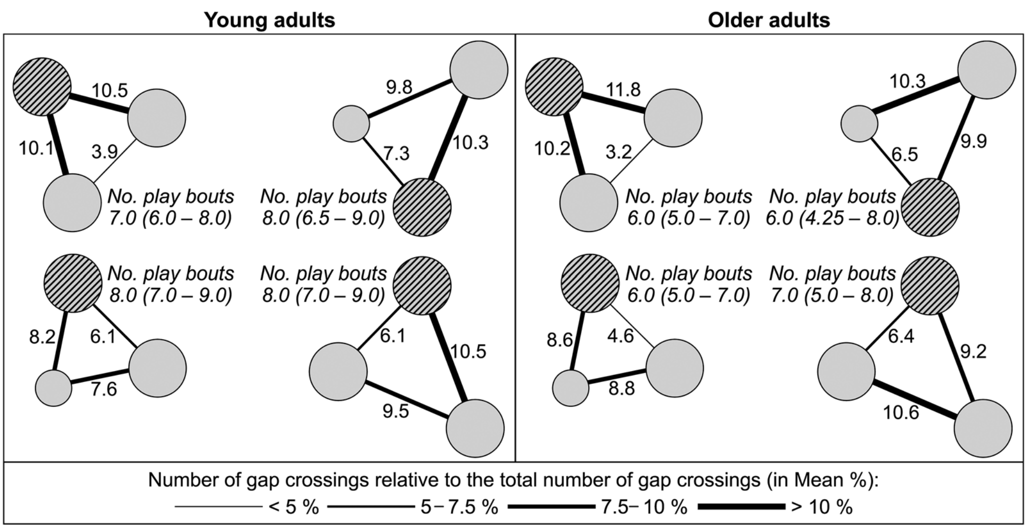

Figure 8. For both young and older adults clockwise from the upper left: the H configuration, H-GW-S configuration, H-GW configuration, and H-S configuration (hatched circle represents the higher stone). Next to each gap we present the average number of crossings as a percentage of the total number of gap crossings (number of times the gap was crossed/ total number of gap crossings * 100)[3]. The thicker the line of the gap, the more frequently the gap was crossed. In addition, the medians and interquartile ranges of the number of play bouts are presented for each configuration.

[3]Two young adults one time crossed two gaps at once. This crossing was counted as two individual gap crossings in Figure 8, but as one crossing in the analysis of the general play behavior.

In addition, the total number of gaps crossed in each configuration (see Figure 9) differed among configurations for young adults ($\chi^2(3) = 10.24$, $p = .017$, Kendall's $W = .14$) but not for older adults ($\chi^2(3) = 6.40$, $p = .094$; Kendall's $W = .08$). Post-hoc tests revealed that young adults not only visited the H-GW configuration more often than the H configuration, but also crossed more gaps in the former than in the latter (see Figure 9).

Furthermore, the configuration had an effect on playtime for both young ($\chi^2(3) = 27.81$, $p < .001$, Kendall's $W = .37$) and older adults ($\chi^2(3) = 18.45$, $p < .001$, Kendall's $W = .22$). In general, most playtime was spent in the configurations including gap width variation (see Figure 10). An explanation for these differences could be that the larger gap widths were more difficult to cross and therefore requested more crossing time and/or the use of extra on-ground steps. Indeed, when we divide the number of

Figure 9. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the total number of gap crossings of young and older adults in each configuration, and the number of gap crossings per minute in each configuration for both groups in Experiment 2. * indicates a significant difference at $p < .05$.

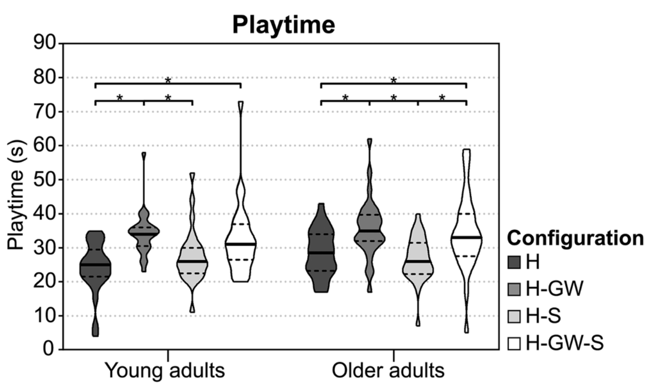

Figure 10. Violin plot with the medians (solid line) and interquartile ranges (dotted lines) of the playtime spent by young and older adults in each configuration of Experiment 2. * indicates a significant difference at $p < .05$.

gap crossings by playtime, less gaps per time unit are crossed within the configurations with gap width variation compared to the other configurations (young adults: $\chi^2(3) = 25.35$, $p < .001$, Kendall's $W = .34$; older adults: $\chi^2(3) = 23.65$, $p < .001$, Kendall's $W = .28$; see Figure 9). Moreover, we analyzed the number of gaps crossed with the help of on-ground steps for both young adults (H: Mdn = 0, IQR= 0 − 0; H-GW: Mdn = 1, IQR= 0 − 2; H-S: Mdn = 0, IQR= 0 − 0; H-GW-S: Mdn = 0, IQR= 0 − 1) and older adults (H: Mdn = 0, IQR= 0–1; H-GW: Mdn = 0, IQR= 0–3; H-S: Mdn = 0, IQR= 0–0; H-GW-S: Mdn = 0, IQR= 0 − 1.75). Young adults made significantly more on-ground steps in the H-GW configuration than in the H and H-S configuration ($\chi^2(3) = 21.33$, $p < .001$, Kendall's $W = .28$). Older adults used significantly more often on-ground steps in all configurations with gap width variation compared to the other configurations ($\chi^2(3) = 19.34$, $p < .001$, Kendall's $W = .23$). Thus, we tentatively suggest that the configurations with larger gap widths were more difficult to cross, which resulted in slower gap crossings.

General discussion

Earlier studies on stepping stones designs found that children, young adults and older adults prefer nonstandardized stepping stones configurations over standardized ones (Jeschke et al., 2020; Jongeneel et al., 2015; Sporrel et al. 2017a). In addition, Jeschke et al. (2022) discovered that children are especially attracted to configurations with variation in stone height. In the present study, we aimed to determine whether this preference is found in people of all ages. To that end, we replicated the study of Jeschke et al. (2022) but now with young and older adults as participants.

The preference for height variation appears to be independent of age

As in the previous study (Jeschke et al., 2022), we analyzed for each configuration both the play behavior (i.e. stepping behavior, playtime, number of play bouts) and the judgments. When we look at the play behavior, we did not observe a clear preference among our participants for one of the configurations. In terms of playtime, some differences between the configurations were observed (especially in Experiment 2). However, we tentatively suggest that the longer playtimes associated with variation in gap sizes had more to do with the time that participants needed to prepare a jump and/or to correct the position of the feet after landing than with the fun experiences in these configurations.

The judgments, on the other hand, did reveal a clear preference for the height variation. In Experiment 1, both the young and the older adults judged the 'height' configuration as more fun than any of the other configurations. Together with the earlier study on children (Jeschke et al., 2022) this indicates that the preference for height variation is age independent. For older adults, this finding was further confirmed in Experiment 2—it was shown that for this group combinations of height variation with size and/or gap width variation did not increase the fun scores (cf. Jeschke et al., 2022). However, young adults judged the H-GW-S as more fun than the H-GW and the height only configuration. Hence, for this group height variation becomes more appealing when combined with gap width and size variation.

How to account for the preference for height variation?

Why are people generally attracted to variation in stone height? Does it have to do with the esthetic appeal of the height configuration? Or are participants attracted to the challenge and/or risk of the differences in height? Our earlier study with children (Jeschke et al., 2022) was not equipped to examine the relationships between these variables because in that experiment the children were asked to rank the configurations, thereby making the judgments dependent of each other. In the present experiments, we overcame this methodological shortcoming by using 9-point Likert scales for the judgments.

The Kendall's tau coefficients indicate that adults, both young and older, are not attracted to the configurations they considered risky or challenging—we did not find a significant relationship between judgments of fun and risk or fun and challenge. Thus, at least for adults, the attractiveness of the height configuration(s) seems to be unrelated to the experienced risk or challenge of the stepping stones landscapes.

However, the judgments of fun and esthetics did seem to be related. In general, we found significant positive correlations between fun and esthetic appeal for each age group and configuration. This finding is not in line with the results of Sporrel et al. (2017a). In their study on standardized and nonstandardized jumping stone configurations for children, judgments of fun and esthetic appeal did not significantly correlate. Hence, they concluded that the esthetic qualities of a configuration might not be a primary concern of a playing child.

There are several explanations for this discrepancy. One explanation could be that the judgment scale of Sporrel et al. (2017a) was not sensitive enough to determine a significant correlation. We used a 9-point Likert scale while Sporrel et al. (2017a) used a 5-point Likert scale. Another explanation could be that adults are more concerned with the esthetics of a configuration than children are. Indeed, as Olwig (1990) argued earlier:

> 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. […] The visual mess and disorder that drives the average parent, let alone the visually trained architect, to distraction is prized by children. (p. 52)

This could mean that although both children and adults prefer height variation over the other examined types of variation, the reason for this preference might be different for the different age groups.

In addition, the preference for height could also be governed by a factor that we have not examined thus far. Perhaps people of all ages appreciate the change of perspective when stepping on the higher stone or like the "kinetic joyride" (Sheets-Johnstone, 2003, p. 416) of stepping up and down. Future studies are needed to determine which factors contribute to the experienced fun of the height configuration, and whether these factors are different for people of different age groups.

On challenge and risk

In the two reported experiments we scrutinized the relationship between challenge and risk. In the earlier study on children (Jeschke et al., 2022) we argued that we should make a distinction between the two. The reason was that we found that, contrary to suggestions in the literature (e.g. Little & Eager, 2010; Sandseter, 2007, 2009, 2021; Stephenson, 2003; Wakes & Beukes, 2012), children were not so much attracted to challenging configurations as to the seemingly risky ones. In the playground literature, the concepts of risk and challenge are often used interchangeably (e.g. Little & Eager, 2010; Mitchell et al., 2006; Stephenson, 2003). Yet, challenge does not necessarily imply risk, and vice versa. To reiterate an example from our previous paper, stepping over a narrow but high cliff might be risky but not physically challenging, while crossing a large distance close to the ground might be physically challenging but less risky.

Yet, judgments on risk and challenge were significantly related to each other in the present study (except for young adults in the standardized configuration). Hence, although challenge and risk can be disentangled on analytic grounds, they were related in our study on stepping stones. In addition, the results of the judgments were supported by the data of the stepping behavior. In Experiment 1, the standardized configuration was judged as the least risky and challenging configuration, and this was the configuration that had, generally speaking, the most crossings per minute of all the configurations. This same pattern was observed in Experiment 2. However, to find out whether the distinction between risk and challenge is useful in the understanding of playing behavior and the preference for certain equipment, further studies are needed in which they are *empirically* disentangled.

Another interesting finding was that older adults rated the configurations in both experiments as less challenging and in Experiment 1 also as less risky than the young adults did. However, because in both experiments older adults showed to have declined action capacities compared to the youngsters, we actually expected these subjective judgments to be the other way around. How to account for this?

One possible explanation for this unexpected observation could be that younger adults overestimate the challenge and risk involved. Or that they used the configurations in a more challenging and/or risky manner. Indeed, whether the crossing of a gap is experienced as challenging or risky, depends not only on the physical dimensions of the gap (e.g. width, height above the ground), but also on how the agent crosses it. For example, Hodges and Lindhiem (2006) showed that parents approach steps more carefully when carrying their child than when carrying groceries—arguably because the consequences of falling (the risks) are perceived to be greater when holding their child. In a similar fashion, the perceived challenge and risk of the configurations can be influenced by the speed at which the gaps are crossed. Thus, it is possible that young adults *crossed* the gaps in a more challenging and risky way than older adults and therefore judged the configurations also as more challenging/risky.

Another explanation could be that older adults were more driven to convince the researchers of their physical competence than young adults. Older adults often have a greater motivation to do well in studies and help the experimenter (Lockwood et al., 2021; Ryan & Campbell, 2021). Since we aimed to create attractive stepping stones landscapes, older adults might have wanted to reassure us that we chose gap widths that were not too difficult or risky to cross for them.

Future studies are needed to determine which of these explanations account for the fact that older adults rated the configurations as less challenging and risky than the young adults did. This requires a more in-depth analysis of the stepping behavior. Recall that in the present study, participants were to step in small configurations for only three minutes. Although this allowed them to determine their preferences for the different configurations, it does not equip us to come to full grips with their natural playing behavior. In addition, participants had to "play" by themselves while playing is generally a social endeavor. Hence, to increase the ecological validity, we recommend future research to carry out field studies with larger stepping stones configurations, placed in a public open space.

Conclusion

Several studies using stepping stones landscapes as a playground and/or fitness area paradigm suggest that the target users themselves are more attracted to variation than to standardization (Jeschke et al., 2020; Jongeneel et al., 2015; Sporrel et al., 2017a). The present study built upon the latter findings and specified what *kind* of variation attracts people the most. Based on the judgments we can conclude that, like children, young and older adults have a preference for variation in stone height. This entails that when playground designers aim to create attractive stepping stones landscapes, they should at least include higher stones in their design to increase the fun-factor. In addition, when a stepping stones landscape is designed for mainly young adults, we recommend to additionally add size and gap width variation to its design.

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The authors report there are no competing interests to declare.

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