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The Effect of Specific Locomotor Experiences on Infants' Avoidance Behaviour on Real and Water Cliffs

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Declaration of Conflicting Interest

The authors declare that there is no conflict of interest.

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ABSTRACT

Infants' avoidance of drop-offs has been described as an affordance learning that is not transferable between different locomotor postures. In addition, there is evidence that infants perceive and act similarly around real and water cliffs. This cross-sectional

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study investigated the effects of specific locomotor experiences on infants' avoidance behaviour using the Real Cliff / Water Cliff paradigm. The experiments included 102 infants, 58 crawling, but pre-walking, infants (M_{age}= 11.57 months, SD = 1.65) with crawling experience ranging between 0.03 and 7.4 months (M = 2.16, SD = 1.71) and 44 walking infants (M_{age} = 14.82 months, SD = 1.99), with walking experience ranging between 0.13 and 5.2 months (M = 1.86, SD = 1.28). The association between crawling experience and crawlers' avoidance of the real and water cliffs was confirmed. Importantly, crawling and total self-produced locomotor experience, and not walking experience, were associated with walkers' avoidance behaviour on both cliffs. These results suggest that some degree of perceptual learning acquired through crawling experience was developmentally transferred to the walking posture. A longer duration of crawling experience facilitates a more rapid recalibration to the new walking capability. In addition, there was no difference in infants' avoidance of falling on the real and the water cliff. However, infants explored the water cliff more than the real cliff, revealing more enticement to examine bodies of water than for drop-offs.

Keywords: perception-action, affordances, falls, drowning, crawling, walking.

INTRODUCTION

During the first months of post-natal life, an infant's size, body's proportions and action capabilities change dramatically. Once they can self-locomote, a whole new world opens up for infants as they are now able to pursue goals at a distance, change

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their location, adopt new vantage points for viewing the environment, and explore objects, events, and people that were previously inaccessible. This exploratory activity has an important role in development, leading to great advances in motor, perceptual and psychological functioning (E. J. Gibson, 1988; Campos, Anderson, Barbu-Roth, Hubbard, Hertenstein & Witherington, 2000; E. J. Gibson & Pick, 2000; Cordovil, Araujo, Pepping, & Barreiros, 2015). However, in their urge to explore the world, infants sometimes engage in unsafe behaviours.

Drowning and falls are, respectively, the second and fourth leading causes of unintentional injury deaths among children worldwide (Peden et al., 2009). Sometimes, falling and drowning occur together. In Australia, for instance, 81% of drowning deaths among children younger than 5-years occur due to a fall into the water (Royal Life Saving Society - Australia, 2016). The World Health Organization (2014) claims that young children, who are mobile but too young to recognize danger, are most vulnerable to drowning incidents.

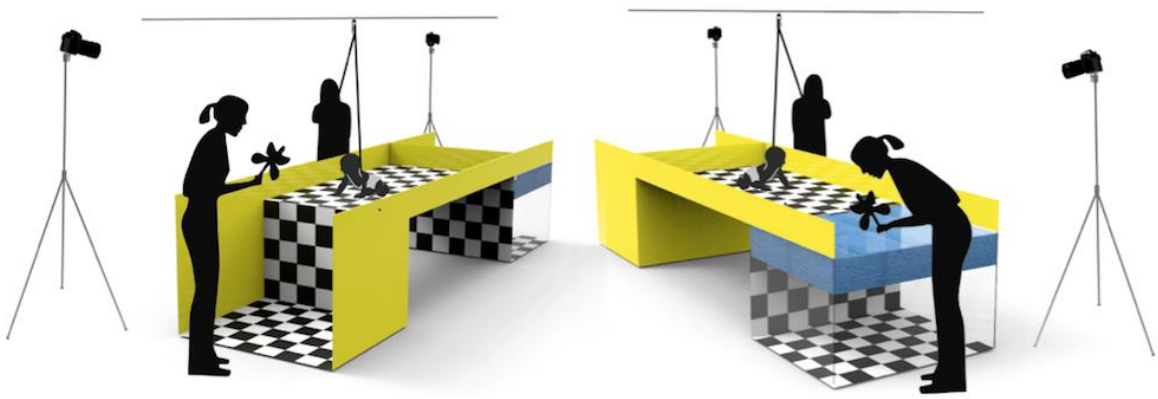
Self-produced locomotion and infants' avoidance of drop-offs

A considerable body of research has investigated the dynamic relationship between young children and environments that can put them at risk of potentially fatal injuries (e.g., drop-offs that are too high to navigate). Avoidance of risky situations ultimately helps to keep us alive but, paradoxically, the infant's curiosity and need to explore risky environments may be one of the driving forces behind skill development and adaptive behaviour (see Plumert, 1995; Cordovil et al., 2015). Since the groundbreaking work of Eleanor J. Gibson and Richard Walk (1960) the classical "Visual Cliff" paradigm (and variations) has been used to investigate the role of locomotor experience on infants' perception and action in risky scenarios (Campos, Bertenthal, & Kermoian, 1992; Witherington, Campos, Anderson, Lejeune, & Seah, 2005; Kretch & Adolph, 2013; Burnay & Cordovil, 2016). Studies using the visual cliff paradigm have reported that crawling (but not pre-crawling) infants showed significant increases in heart rate when lowered onto the deep side of the visual cliff and that prior crawling experience was the strongest predictor of avoidance of the visual cliff. The authors reported that 60-80% of experienced crawlers avoided the deep side of the visual cliff while only 30-50% of new crawlers did so (Bertenthal & Campos, 1984; Campos et al., 1992). An interpretation of this finding is that locomotor experience contributes to the development of wariness of heights (Bertenthal & Campos, 1984; Campos et al., 1992; Campos et al., 2000).

Variations of the visual cliff paradigm have confirmed that although infants exhibit highly adaptive avoidance behaviour around drop-offs, they do not reliably avoid them until after they have acquired weeks of independent locomotion experience. Adolph (1997) reported that, when descending slopes, inexperienced crawlers moved headfirst down risky slopes but, after weeks of crawling experience, they only crawled down safe slopes and slid down or avoided risky ones. Likewise, when testing infants on a real cliff (Kretch & Adolph, 2013), experienced crawlers avoided drop-offs that were too high to climb down safely. To investigate if self-produced locomotor experience influences infants' adaptive behaviour around drop-offs and bodies of water, Burnay and Cordovil (2016) created the Real Cliff / Water Cliff apparatus. The apparatus consisted of a 0.75 m high platform with a real cliff at one end and a "water cliff" (i.e., plexiglass tub filled with water) on the opposite side (see Figure 1).

Burnay and Cordovil (2016) tested infants with varying ages, crawling onsets and amounts of crawling experience. Specifically, crawling experience was shown to be the best predictor of crawling infants' avoidance behaviour, on both cliffs. This study confirmed an association between self-produced locomotor experience and infants' avoidance of falling on dryland drop-offs and showed the same relationship existed for water cliffs. When comparing infants' behaviour between the real cliff and the water cliff, the majority of infants (71%) showed the same avoidance behaviour (Burnay & Cordovil, 2016), suggesting that similar perception and action processes are present in both environments.

FIGURE 1 | Real Cliff (left) / Water Cliff (right) experimental set-up. Illustrated here side-by-side for contrast but conducted independently. From Burnay, C., & Cordovil, R. (2016). Crawling experience predicts avoidance of real cliffs and water cliffs: Insights from a new paradigm. Infancy, 21(5), 677-684. Copyright © 2016, John Wiley and Sons, reprinted with permission.



The transition from crawling to walking and infants' avoidance of risky scenarios

The link between self-produced locomotor experience and infants' perception and action around risky drop-offs (whether visual cliffs, impossible steep slopes, dryland or water drop-offs) is now well established and universally accepted among researchers (see Anderson, 2018; Adolph, 2019). However, when infants start walking a new perspective on the world emerges. Whilst walking, infants no longer contact the surface of support with their hands and this new bipedal locomotion introduces new postural and balance demands. In essence, walking is a new perceptual-motor challenge to infants and its emergence raises interesting questions about its effect on perception and action around drop-offs.

When testing infants on increasingly steeper slopes, Adolph (1997) reported that experienced crawlers avoided risky slopes but, in a newly acquired walking posture, they fell while trying to march straight down steep slopes. Similarly, experienced crawlers avoided falling, but newly walking infants tried to walk over the edge of 'impossible to traverse' real cliffs (Kretch & Adolph, 2013). Only after weeks of walking experience did walkers start adapting their behaviour again to avoid steep slopes (Adolph, 1997) and high drop-offs (Kretch & Adolph, 2013). In addition, within-subject studies comparing the same experienced sitters and novice crawlers on gaps (Adolph, 2000) showed that infants adopt more adaptive behaviours when tested in an experienced posture then in a newly acquired one. In light of this functional discontinuity between postural and locomotor milestones and the role of posture-specific experience on infants' adaptive avoidance of dangerous scenarios, Adolph (2000) proposed a 'sway model'. The sway model suggests there are four different perceptual learning curves in development as infants learn to sit, crawl, cruise, and walk. From this perspective, avoiding cliffs has been described as posture-specific affordance learning that is not transferable between different locomotion patterns (see Adolph, 2019).

In contrast to the posture-specific hypothesis, one piece of evidence suggests that what infants learn about negotiating a visual cliff from a crawling posture transfers to a new walking posture. Witherington et al. (2005) reported that newly walking infants avoided the deep side of a visual cliff more consistently than age-matched experienced crawlers. The authors argued that a developmental transfer of wariness of heights occurred across postural milestones and that avoidance of drop-offs is established through crawling experience and developmentally maintained once infants begin walking.

Different experimental paradigms, different outcomes

The contradictory results on the transfer of learning from a crawling to a walking posture may be at least partly due to differences in experimental paradigms. These differences are especially apparent when comparisons are made between the visual cliff used by Witherington et al. (2005) and the real cliff used by Kretch and Adolph (2013). First, the experimental paradigms were different. The visual cliff has a glass surface that creates a conflict between visual and haptic information and modifies the infants' possibilities for exploratory behaviour on the deep side (see Adolph & Kretch, 2012). To avoid these problems, Kretch and Adolph (2013) used a real cliff paradigm where the drop-off is identical to the visual cliff, except for the presence of a glass. In that case, to ensure the infants' safety, an experimenter stays close to them and catches them if they begin to fall. Although there is evidence that the spotter's presence does not lead infants to behave rashly (Adolph, 2000), this procedure makes it difficult to determine how infants would behave in the absence of an adult hovering so close to them. In addition, Witherington et al. (2005) coded "crossings" when all four limbs were placed on the deep side of the visual cliff, which underestimates the number of infants who would have fallen over the edge of a real cliff during poorly controlled attempts to explore the cliff edge (see Adolph & Kretch, 2012; Adolph, Kretch, & LoBue, 2014). Second, Witherington et al. (2005) and Kretch and Adolph (2013) used different study designs. Witherington et al. (2005) tested infants only once on the visual cliff in order not to induce any progressive learning; while Kretch and Adolph (2013) used a psychophysical staircase procedure, where infants were progressively introduced to incrementally deeper stairs (sometimes in large jumps based upon the outcome of previous trials) until there was a reversal in behaviour, in which case the depth became shallower before increasing again. Although this staircase procedure avoids drawing conclusions based on just one trial, it may not be suitable to directly test avoidance behaviour of infants when presented with a dangerous cliff in a real environment, where a single trial may have definitive consequences.

One similarity between the Kretch and Adolph (2013) and Witherington et al. (2005) approaches is that both compared age-matched experienced crawlers and new walkers. By comparing the behaviour of one group of experienced crawlers with one group of newly walking infants, holding age constant, the effects of age and specific locomotor experiences cannot be accessed. New walkers may avoid the apparent drop-off from a visual cliff more consistently or they may fall more from the real cliff than experienced crawlers, but it is unclear whether the reason for this difference is the amount of walking experience the infants have acquired.

Infants' perception and action around water environments

"Water cliffs" (i.e., drop-offs filled with water), are physical cliffs that pose a specific risky scenario for children. The open air at the brink of a cliff and the surface of a body of water offer different visual and tactile information but they are both "preventer(s) of locomotion" (J. J. Gibson, 1979, p.36) and potentially dangerous to the infant. Yet, perhaps surprisingly, whether infants recognise the risk associated with bodies of water and act accordingly has received little attention.

Most studies in the field of children's drowning prevention have adopted an epidemiological approach (Peden et al., 2009). These studies do not directly address when and why children learn to perceive the risk of a body of water and how they adapt their behaviour accordingly. However, some studies have analysed the behaviour of infants on surfaces offering tactile or visual cues for water. For instance, E. J. Gibson et al. (1987) tested the avoidance and exploratory behaviour of infants on a deformable waterbed versus a rigid plywood surface. Crawlers showed similar latency for initiation of traversal between the two different surfaces, a similar amount of visual and haptic exploratory behaviour, and crossed them both in equal numbers. Rader (2003) reported having tested infants on the visual cliff with water under the glass in three conditions: opaque water with waves, opaque water without waves, and a normal shallow side (without water). The results showed that infants' latency to leave the centreboard was shortest in the moving water condition. The author concluded that infants do not always respond to the affordance of non-support even when visual information specifies a non-rigid surface. However, in neither study (i.e., E. J. Gibson et al., 1987; Rader, 2003) did the infant have the opportunity to touch the water and, in both situations, the surfaces (waterbed and glass) were safe for quadrupedal locomotion, eliminating the possibility of falling into the water. One specific study by Cordovil, Santos, and Barreiros (2012) analysed 1-4-year-olds' (all walkers) risk-taking and exploratory behaviour nearby actual water surfaces. It showed that 69% fell or jumped into the water to grasp the toy when it was beyond their reaching limit. The authors reported that locomotor experience was not significantly related to children's behaviour. However, of the 68 children tested, only one had less than 30 days of walking experience, so newly walking infants' behaviour could not be addressed.

The Real Cliff / Water Cliff paradigm (Burnay & Cordovil, 2016) (see Figure 1), was designed to overcome some of the limitations highlighted in previous studies. The transparent glass (used in visual cliff studies) and the presence of an experimenter alongside the infant (used by Adolph and colleagues) were replaced by a harness

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system to ensure the infants' safety. This removed the possible bias from these experimental features and allowed the infants to safely explore the real cliff and the water cliff visually and haptically. Infants were tested only once on each cliff, in order to replicate how an infant would behave upon first encountering a novel drop off. Finally, to provide a reliable estimate of the amount of locomotor experience required for infants to start avoiding drop-offs, age and crawling experience were allowed to vary considerably (Burnay & Cordovil, 2016). However, Burnay and Cordovil (2016) only tested crawling infants and the question of whether walking experience influences walking infants' avoidance behaviour as strongly as crawling experience affects crawling infants' avoidance behaviour remains unanswered.

Present study

The present study examined crawling and walking infants' avoidance of falling from heights and into the water using the Real Cliff / Water Cliff apparatus. The main aim of this study was to investigate the impact of specific locomotor experiences on infants' perception and action around real and water cliffs. Age and locomotor experience varied considerably in the sample enabling us to estimate the predictive strength of specific locomotor experiences on avoidance behaviour on both cliffs. If "crawling experience teaches infants to perceive affordances for crawling and walking experience teaches infants to perceive affordances for walking" (Kretch & Adolph, 2013: p. 236), then crawling infants' avoidance behaviour would be linked to the

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amount of crawling experience and walking infants' avoidance behaviour would be linked to the amount of walking experience.

A second goal was to compare infants' avoidance and exploratory behaviours on the real and the water cliffs while searching for information to decide whether or not to crawl/walk over the edges. A real cliff (filled with air) and a water cliff (filled with water) are visually and haptically different, but they are both preventers of safe terrestrial locomotion. Infants' similar behaviours on the real and the water cliffs would confirm a similar perception of affordances on both drop-offs (Burnay & Cordovil, 2016).

METHODS

Participants

A total of 102 infants were tested on the Real Cliff / Water Cliff apparatus. Of these, 58 (30 boys and 28 girls) were crawling on their hands-and-knees (but not walking) and 44 (25 boys and 19 girls) had started walking. Note that the sample of crawling infants from Burnay and Cordovil (2016) was enlarged from 31 to 58, to improve confidence in original findings (see Lukits, 2016). There were no significant differences in age and locomotor experiences between the crawling infants tested in Burnay & Cordovil (2016) and the 27 crawlers added to the sample in the present study. Six additional crawlers and seven walkers were excluded from the sample due to compulsive crying or fussiness prior to or during the first 60 s of the trials. Families were recruited through

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referrals, social network advertisements, and local schools, in the metropolitan area of Lisbon, Portugal. (CEFMH Approval Number: 15/2014).

Walkers were older and had more crawling, cruising and total self-produced locomotor experience than crawlers (see Table 1).

TABLE 1 | Difference in age and locomotor experience durations (in months) between crawlers (N=58) and walkers (N=44).

		Min	Max	Mean	SD	*t*	*p*
Age	Crawlers	8.51	16.13	11.57	1.65	-8.99	<.001
	Walkers	10.35	18.56	14.82	1.99		
Belly-Crawling experience	Crawlers	0.00	4.50	1.12	1.18	1.44	0.154
	Walkers	0.00	7.46	0.75	1.41		
Crawling experience	Crawlers	0.03	7.36	2.16	1.71	-5.87	<.001
	Walkers	0.00	6.74	4.09	1.55		
Cruising experience	Crawlers	0.00	6.80	1.15	1.27	-6.27	<.001
	Walkers	0.00	7.92	3.23	1.90		
Walking experience	Crawlers	-	-	-	-		
	Walkers	0.13	5.19	1.86	1.28		
Total Self-Locomotor experience	Crawlers	0.39	7.36	3.28	1.93	-8.71	<.001
	Walkers	0.13	5.19	6.73	2.04		

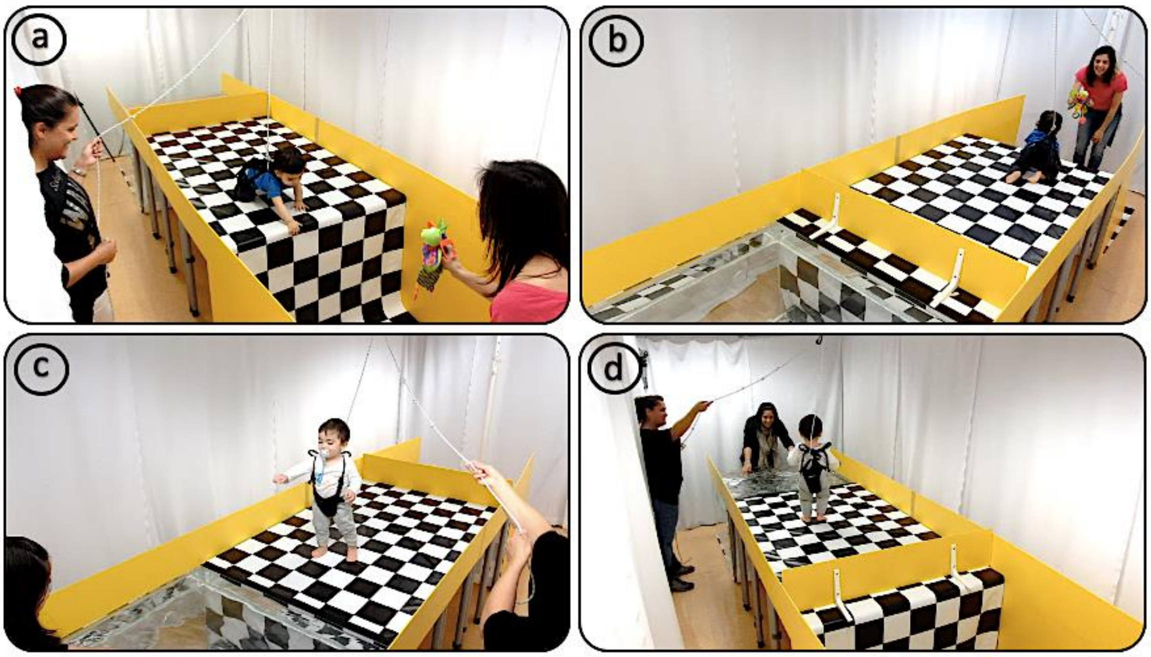
Crawlers' crawling experience was not significantly different from walkers' walking experience, *Welch's F* (1, 99.98) = 1.059, *p* = .306. The amounts of specific locomotor experiences were calculated from the onset dates reported by the mothers: *Belly-crawling experience* – since the day the infant first belly-crawled (with belly touching the floor, for at least five continuous cycles) until the day the infant first hands-and-knees crawled (for at least five consecutive cycles, without the belly touching the floor); *Crawling experience* – since the day the infant first hands-and-knees crawled until the trial day, in the case of pre-walking infants, and until the day the infant first walked (for at least ten consecutive steps, with no external support), in the case of walking infants; *Cruising experience* – since the day the infant first walked with the support of home furniture (lateral locomotion, for at least ten consecutive steps) until the trial day, in the case of pre-walking infants, and until the day the infant first walked, in the case of walking infants; *Walking experience* – since the day the infant first walked independently until the trial day; *Total self-produced locomotor experience* – since the day the infant first self-locomoted (by belly-crawling, hands-and-knees crawling, cruising, or walking) until the trial day.

The criterion used to determine the onset of locomotor skills was functional, derived from task-specific variables, as observed in previous studies (e.g., Adolph, 1997; Witherington et al., 2005). The five-cycle criterion used for the onset of belly-crawling and crawling (as in Burnay and Cordovil, 2016), and ten-steps for walking onset correspond approximately to the 2-m-length infants had to crawl or walk on the platform to get to the edge. Adolph (1997) defined crawling onset as the day infants could travel 91 cm along a flat path. Therefore, it is likely that an infant with one week of experience on Adolph's (1997) criterion is less experienced than an infant with one week of experience in the present study. Regarding the criteria used to determine walking onset, Adolph (1997) used 321 cm while Witherington used 184 cm. Therefore, walking experience would be similar between infants in the present study and those in Witherington et al.'s (2005) study but an infant with one week of walking experience in the present study would have less walking experience than infants with one week of walking experience in Adolph's (1997) study.

Real Cliff / Water Cliff Apparatus

The Real Cliff / Water Cliff apparatus is the same as that used in Burnay and Cordovil (2016). As shown in Figure 1, the apparatus consists of a 200 x 120 x 75 cm platform, coated with a black and white checkerboard pattern and with a real cliff at one end and a water cliff at the opposite end. Climbing equipment, that did not constrain the infants' movements, was used to ensure infant's safety.

FIGURE 2 | Synchronised camera views of Real Cliff / Water Cliff apparatus: a) Front view of Real Cliff. b) Back view of Real Cliff. c) Front view of Water Cliff. d) Back view of Water Cliff.



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During the time infants were exploring the setting and until the moment they started falling, the rope attached to the harness was hanging loose, not supporting the infants' weight. When infants started falling, a safety mechanism limited the fall to a maximum of 5 cm (see Figures 1 and 2).

On the water cliff, the water level is continuous with the level of the platform, therefore, when the solid platform ends, the water surface starts. The 75 cm height was chosen because it corresponds to the common height of home tables. In addition, 75 cm is more than two times the 30 cm height drop-off defined by Sorce, Emde, Campos, and Klinnert (1985) as a threshold of uncertainty at which infants would rely on mothers' social information to decide whether or not to cross the deep side of the visual cliff and beyond which avoiding infants would not go over a drop-off even when the mothers were encouraging them to do so.

Procedure

All the procedures were the same as those used by Burnay and Cordovil (2016). Before visiting the laboratory, information about the study was sent to the mothers, who were asked to use their baby books, photos and films in order to remember the different onset-dates of their infants' achievements. Mothers were asked to use pictures/videos and diaries to report their infants' locomotor onset dates before testing.

Infants were tested once on the real cliff and once on the water cliff, with trial order counterbalanced across infants. Mothers were asked to help the examiner put

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the harness on the infants and to hold the infants on their laps while the examiner attached the safety rope to the harness. Then, to familiarize the infants with general characteristics of the setting, the mothers first placed the infants on the platform (150 cm away from the edge) and played with them. When the infants were calm and showing no sign of distress, mothers went to the opposite end of the platform facing the infant, 1 m away from the cliff. Next, the experimenter placed the infants close to the opposite edge of the platform (2 m away from the edge of the cliff being tested) in a hands-and-knees position, if the infant was a crawler, and in an upright position, if the infant was a walker, and initiated the trial. Mothers were instructed to encourage their infants to move toward them by waving a toy and using positive verbal and gestural communication. In the water cliff condition, mothers were instructed to touch the water so the infant could receive the visual information of water. Infants were dressed in typical clothing and the water was at room temperature (about 20°C).

The experimenter followed the infants' movements by walking alongside the platform and staying a minimum of 50 cm away from the platform. After the trial was initiated, the experimenter would only interfere with the infants' movements if they did not move from the starting position during the first minute, in which case the experimenter would place them near the platform edge (with hands, in the case of crawlers, or feet, in the case of walkers, touching the platform within 10 cm of the edge). The trials ended: (a) after 180 s, if the infant had moved from the starting position but had not reached the platform edge; (b) 150 s after the infant reached the platform edge; (c) when the infant fell off or descended from the platform edge; (d) when the infant started showing signs of distress or fussiness. If the infant showed signs of distress or fussiness during the first 60 s of the trial and was not able to be calmed down, the test was ended and the infant was excluded from subsequent analyses. If the infant showed signs of distress or fussiness after 60 s of reaching the edge, the test was ended, and the infant was coded as an avoider. After completion of the trial, the experimenter changed the platform end-barrier to the opposite end, and the procedure was repeated on the other cliff condition.

Infants were free to move around on the platform while their mothers were calling them, adopt any locomotor posture to explore the apparatus, stop, detour, sit down, stand up again, touch the water (on the water cliff) or stretch their arms and feet to the floor (on the real cliff), while testing their capabilities and seeking information about the possibilities (or impossibilities) of action the setup was offering. Trials were filmed with two cameras for further data analysis.

Data Reduction

From analysis of video, infants were classified as 'fallers' or as 'avoiders'. Infants who fell from the platform, due to loss of balance while exploring the edge or because they tried to locomote over the edge, were coded as fallers. Infants who stayed on the platform until the end of the trial or adapted their behaviour by turning around, laying their bellies on the platform and safely descending feet first, were coded as avoiders.

Infants' exploratory behaviours were also coded from the videos: *Approaching time (seconds)*: starting from the moment the infants were placed in the starting position and ending when they reached the edge of the cliff. If the infants did not leave the starting position 60 s after the trial started, the experimenter placed them on the edge of the platform and the approaching time was coded as missing; *Latency time (seconds*): from the moment the infant reached the platform edge until the end of the trial. If the infants moved from the starting position but did not get to the platform edge 180 s after the trial started, the trial was ended and latency time was coded as missing; *Tactile exploration time (percentage of latency time)*: accumulated duration of periods in which infants' hands or feet went below the line of the platform, touching the water or reaching down towards the floor, until the moment they touched any other surface (apparatus or own body); *Posture of exploration (percentage of latency time)*: accumulated duration of periods in which infants assumed a sitting, lying prone (lying with the belly touching the platform), crawling (quadruped posture with hands and knees or feet touching the platform), squatting, or upright posture; *Pre-Fall posture (sitting*, *lying prone*, *quadruped*, *squatting*, *upright*): posture adopted at the moment the infants fell or locomoted over the platform edge; *Retreat behaviour (yes/no)*: if after getting to the platform edge infants moved away from it at least once.

Avoidance and exploratory behaviours were coded separately for the real cliff and the water cliff conditions. Two observers coded 54% of the crawlers' data and 45% of the walkers' data to ensure interrater reliability. Percentage of interobserver agreement was 100% (k=1.00) for avoidance and retreat behaviours, both for crawlers and walkers. Percentage of agreement for falling posture for walkers on both cliffs and crawlers on the real cliff was 100% (k=1.00); for crawlers, in the water cliff condition, percentage of agreement for falling posture was 91% (k=0.76). The intraclass correlation coefficients for the postures of exploration, tactile exploration, latency time and approaching time were all greater than .97 for crawlers and greater than .95 for walkers.

RESULTS

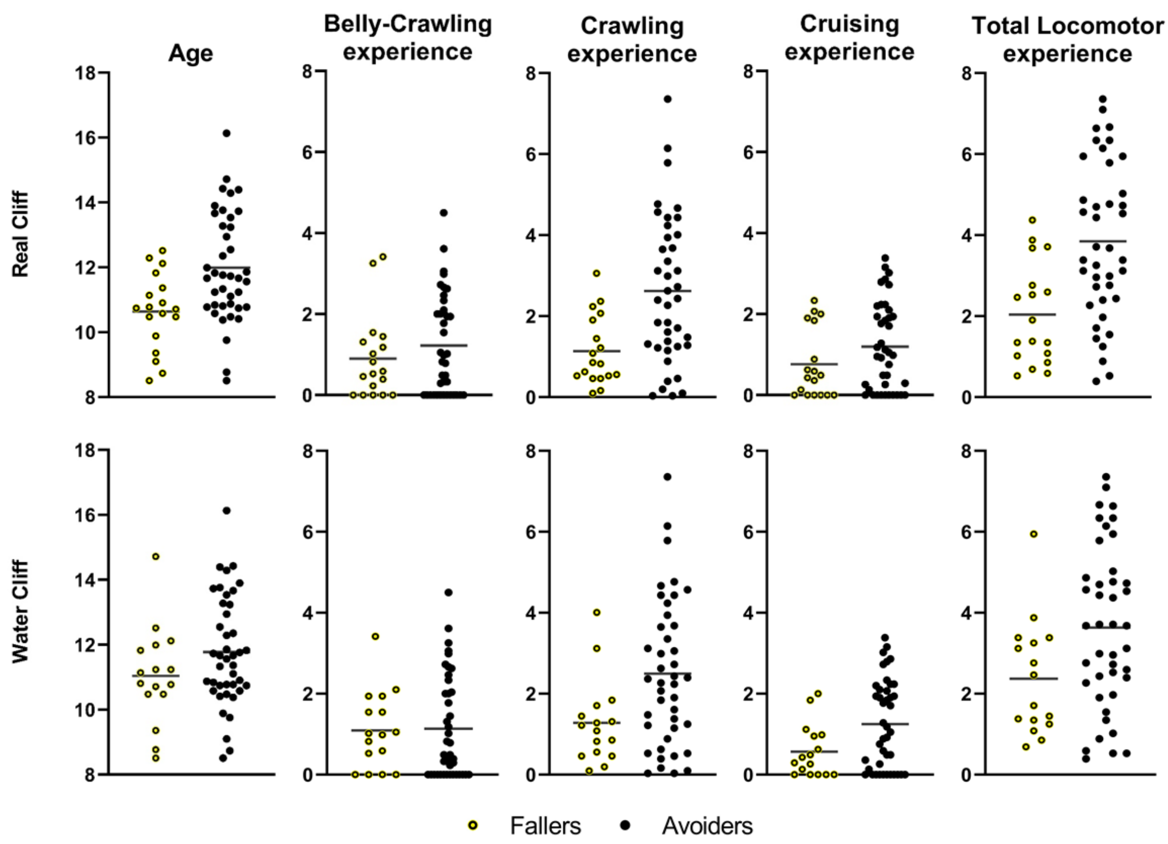
Nine infants on the real cliff (five crawlers and four walkers) and two crawlers on the water cliff started showing signs of distress after 60 s from the trial start. These infants were coded as avoiders and their exploratory behaviours were analysed as a percentage of total latency time. Due to technical errors with filming, a small percentage of data was lost. Three crawlers (5%) on the water cliff condition were not coded for tactile exploration, two crawlers (3%) on the water cliff were not coded for posture of exploration, two crawlers (3%) and one walker (2%) on the water cliff were not coded for visual exploration during approaching time and one walker (2%) on the water cliff condition was not coded for visual exploration during the entire trial.

Crawlers

Preliminary analyses revealed no effect of sex or trial order on the crawlers' avoidance behaviour, on the real cliff nor on the water cliff. As such, these variables were collapsed for subsequent analyses.

Avoidance behaviour - Of the 58 crawlers tested, eight (14%) fell over the edge of both cliffs, 32 (55%) avoided falling on both sides, ten (17%) fell only on the real cliff and eight (14%) fell only on the water cliff. Therefore, 69% of the crawlers showed the same avoidance behaviour on both cliffs. No significant differences in the crawlers' avoidance behaviour between the real cliff and the water cliff were found.

FIGURE 3 | Age and posture-specific locomotor experiences (in months) of avoiding and falling crawlers on the real and water cliff.



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Two avoiders on the real cliff and one on the water cliff turned their belly to the platform and descended feet first. Figure 3 shows age and posture-specific locomotor experiences of avoiding and falling crawlers on the real and the water cliff.

Correlation tests revealed a positive but weak correlation between age and cruising experience (r(56) = .50, p < .001) and between total self-produced locomotor experience and belly-crawling (r(56) = .48, p < .001) and cruising experiences (r(56) = .52, p < .001); positive and moderate correlations between age and crawling (r(56) = .65, p < .001) and total self-produced locomotor experiences (r(56) = .63, p < .001) and between crawling and cruising experiences (r(56) = .63, p < .001); and a positive and strong correlation between crawling and total self-produced locomotor experience (r(56) = .80, p < .001). Initial analysis showed that all VIF values were under 4, indicating that multicollinearity between the variables associated with the crawlers' avoidance behaviour on both cliffs was not a concern (Midi, & Bagheri, 2010).

Logistic regressions were performed to investigate whether avoidance behaviour can be predicted based on age and specific locomotor experiences. Akaike Information Criterion (AIC), recently advocated to assess the adequacy of statistical models in motor behaviour research (Symonds & Moussalli, 2011; Lohse, Shen & Kozlowski, 2020), was used to compare models and select the one that better explained the data. AIC is an estimator of out-of-sample prediction error. The model with the lowest AIC is referred to as the AIC-best model and the differences in AIC (Delta AIC) reflect comparative model fit. A common rule of thumb is to consider models within two AIC units of the AIC-best model as having substantial support

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(Burnham and Anderson 2004). To analyse which would be the AIC-best model we first entered age and each locomotor experience individually in logistic regression models, then all the significant predictors together and finally the two predictors with AIC-best scores when analysed alone.

TABLE 2 | AIC scores for logistic regression models for crawling infants' avoidance behaviour on the real and the water cliff.

Real Cliff			Water Cliff		
	AIC	Delta AIC		AIC	Delta AIC
Age	66.23	3.19	Age	69.91	4.70
Belly-crawling experience	74.86	11.82	Belly-crawling experience	72.31	7.10
Crawling experience (Ce)	63.93	0.89	Crawling experience	65.21	0
Cruising experience (Cru.e)	73.42	10.38	Cruising experience	66.60	1.39
Self-produced Loc. exp. (SLe)	63.04	0	Self-produced Loc. exp.	66.85	1.64
Ce + SLe + Age†	65.39	2.35	Ce + Cru.e + SLe†	68.06	2.90
Ce + SLe‡	63.87	0.83	Ce + Cru.e‡	66.20	0.99

† Model including variables with significant effect on the likelihood that crawlers avoid falling.
‡ Model including variables with lowest AIC values when analysed alone.

In the real cliff condition, the logistic regression models showed a significant association between age ($\chi^2(1) = 7.11$, $p = .008$), crawling ($\chi^2(1) = 7.82$, $p = .005$) and total self-produced locomotor experience ($\chi^2(1) = 9.03$, $p = .003$) and crawlers' avoidance behaviour. Based on the results of Table 2, we can observe that the AIC-best logistic regression model of crawling infants' avoidance of falling on the real cliff is the one with total self-produced locomotor experience as single predictor. The model explains 28% of the variance in avoidance behaviour (Nagelkerke R^2), correctly classifies 74% of cases and indicates that when total self-produced locomotor

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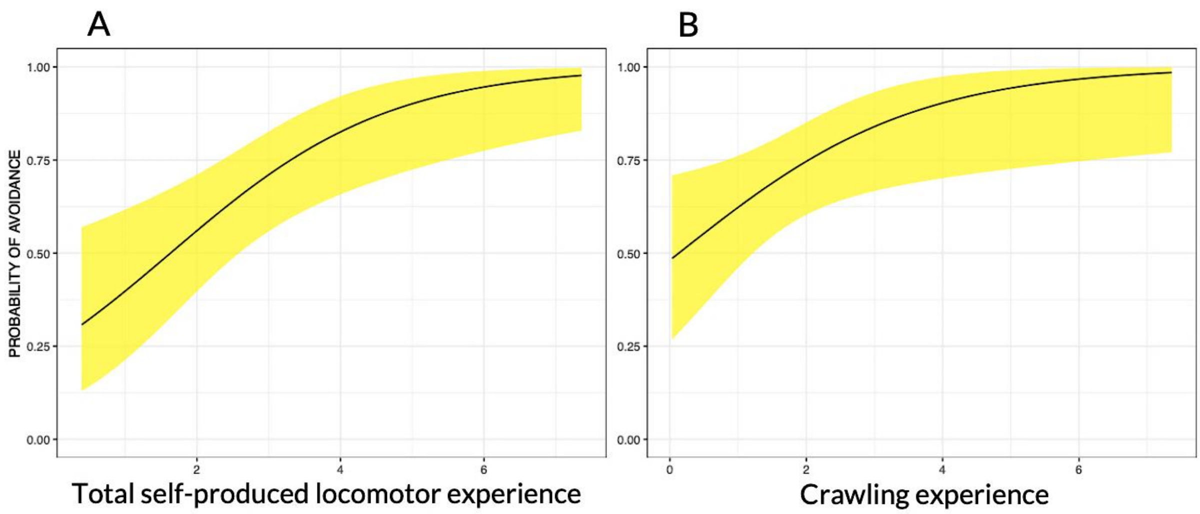
experience increased by 1 month, the odds of avoiding the real cliff increased by 1.93 times with 95% confidence interval (1.26, 2.96) (see Figure 4.A). Models with crawling experience alone and with the combination of crawling and total self-produced locomotor experiences are within two units of the best-AIC model.

FIGURE 4 | The fitted AIC-best logistic models for crawlers' avoidance of the real cliff (A) and water cliff (B). For the real cliff (A), self-produced locomotor experience (in months) is the predictor of probability of avoidance, while for the water cliff (B), the predictor is crawling experience (in months). In both plots, the solid black line gives the fitted value with 95% confidence interval in yellow.



In regard to the crawling infants' avoidance of the water cliff, logistic regression models with crawling ($\chi^2(1) = 5.26$, $p = .022$), cruising ($\chi^2(1) = 4.62$, $p = .032$) and total self-produced locomotor experience ($\chi^2(1) = 4.61$, $p = .032$) were statistically significant. The model with crawling experience alone was the AIC-best model (Table 2), explaining 17% of variance in avoidance behaviour (Nagelkerke R^2), correctly classifying 69% of cases and estimating that the odds of avoidance of falling on the water cliff are 1.78 times higher for each increased month of crawling experience with

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95% confidence interval (1.09, 2.92) (see Figure 4.B). Models with cruising and total self-produced locomotor experiences alone and the combinations of crawling and cruising experiences are within two units of the AIC-best model.

Approaching time - Four crawlers on the real cliff (one faller and three avoiders) and 11 on the water cliff (all avoiders) did not move from the starting position during the first 60 s of testing. These infants were placed on the cliff edge and approaching time was coded as missing. One avoiding crawler on the real cliff moved away from the starting position but never got to the edge; approaching time for this infant was coded as 180 s and latency time and exploratory behaviours during latency time were coded as missing. There was no significant difference in crawlers' approaching time between water cliff (M = 21.91 s, SD = 22.92) and real cliff (M = 36.03 s, SD = 42.38) ($Z = -1.606$, $p = .185$) conditions nor between avoiders (M = 37.05 s, SD = 43.29) and fallers (M = 33.82 s, SD = 41.53) on the real cliff ($U = 304$, $p = .845$) or between avoiders (M = 25.96 s, SD = 25.21) and fallers (M = 14.06 s, SD = 15.79) on the water cliff condition, $U = 163$, $p = .056$.

Latency time - For three avoiding crawlers on the real cliff (61 s, 62 s, 95 s) and two avoiders on the water cliff (60 s, 101 s) latency time was less than 150 s as they started crying after 60 s of testing. Latency time was not significantly different between real cliff (M = 45.62 s, SD = 30.42) and water cliff (M = 45.46 s, SD = 41.51) conditions for falling crawlers, $Z = -0.280$, $p = .779$.

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Tactile exploration time - Five avoiders and one faller never engaged in tactile exploration on the real cliff and six crawlers (two fallers) never touched the water. Statistically, crawlers engaged in more tactile exploration on the water cliff (M = 44.13%, SD = 29.31) than on the real cliff (M = 29.90%, SD = 28.26), Z = -2.802, p = .005. Crawlers that fell (M = 51.86%, SD = 31.07) engaged in more tactile exploration than avoiders (M = 19.77%, SD = 20.28) on the real cliff, U = 136.5, p < .001. However, on the water cliff, fallers' (M = 55.94%, SD = 29.46) and avoiders' (M = 39.28%, SD = 28.20) tactile exploration was not significantly different, U = 207, p = .052. There was no significant difference in tactile exploration time between fallers on the real cliff (M = 51.86%, SD = 31.07) and on the water cliff (M = 55.94%, SD = 29.46), U = 128, p = .581. However, avoiders engaged in more tactile exploration on the water cliff (M = 34.40, SD = 22.87) than on the real cliff (M = 23.61, SD = 27.55), U = 449.5, p = .002.

Posture of exploration - There were no significant differences between real and water cliff conditions in time crawlers spent in a sitting (RC: M = 43.02%, SD = 33.55; WC: M =43.10% , SD =37.92), lying prone (RC: M = 8.26%, SD = 21.55; WC: M = 5.16%, SD = 18.66), or quadrupedal posture (RC: M = 43.91%, SD = 31.67; WC: M = 47.32, SD = 36.81) while exploring the setting. When analysing the differences in the time spent adopting different postures of exploration between avoiders and fallers, on both cliffs, fallers spent more time in a quadrupedal posture (RC: M = 70.64%, SD = 28.22; WC: M = 83.34%, SD = 17.59) than avoiders (RC: M = 31.57%, SD = 25.04; WC: M = 32.91%,

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SD = 32.35) (RC: U = 128, p < .001; WC: U = 80.5, p < .001) and avoiders spent more time in a sitting posture (RC: M = 54.53%, SD = 30.97; WC: M = 56.65%, SD = 35.53) than fallers (RC: M = 18.07%, SD = 24.52; WC: M = 9.24%, SD = 16.67), RC: U = 110, p < .001; WC: U = 73, p < .001. Only one crawler ever adopted the squatting and upright posture during the real cliff testing condition.

Falling posture - Fourteen of the 18 crawlers that fell on the real cliff (78%) and 13 of the 16 water cliff fallers (81%) fell when exploring the edge in a quadrupedal posture. Three crawlers on the real cliff and two on the water cliff fell when adopting a sitting posture and one on each cliff fell while adopting a lying prone posture.

Retreat behaviour - One crawler was not coded for retreat behaviour on the real cliff as he never got to the edge during the 180 s of testing. Crawlers retreated more from the edge of the real cliff (63%) than from the edge of the water cliff (40%) (p = .015, McNemar's test). More avoiding (82%) than falling crawlers (22%) moved away from the edge of the real cliff, χ(1) = 18.946, p < .001. Likewise, more avoiders (50%) than fallers (19%) retreated from the edge of the water cliff, χ(1) = 4.665, p = .031.

Walkers

No effect of sex or trial order was found on the walkers' avoidance behaviour on the real cliff nor on the water cliff. These variables were collapsed for subsequent analyses.

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Avoidance behaviour - Eight (18%) walking infants fell in both conditions, 21 (48%) avoided falling from both cliffs, eight (18%) fell only on the real cliff and seven (16%) fell only on the water cliff. The majority of walkers (66%) showed the same avoidance behaviour on both cliffs. No significant difference was found in the proportion of walkers that avoided falling on the real and the water cliff. Twelve (43%) real cliff avoiders and three (10%) water cliff avoiders safely descended from the platform. Statistically, there were no significant differences in age or any of the locomotor experiences between walking avoiders that stayed on the platform and those who descended on the real cliff. Mean and individual values of age and self-produced locomotor experiences of avoiding and falling walkers on the real and the water cliff are shown in Figure 5.

FIGURE 5 | Age and specific-locomotor experience (in months) for falling and avoiding walking infants on the real and the water cliff.

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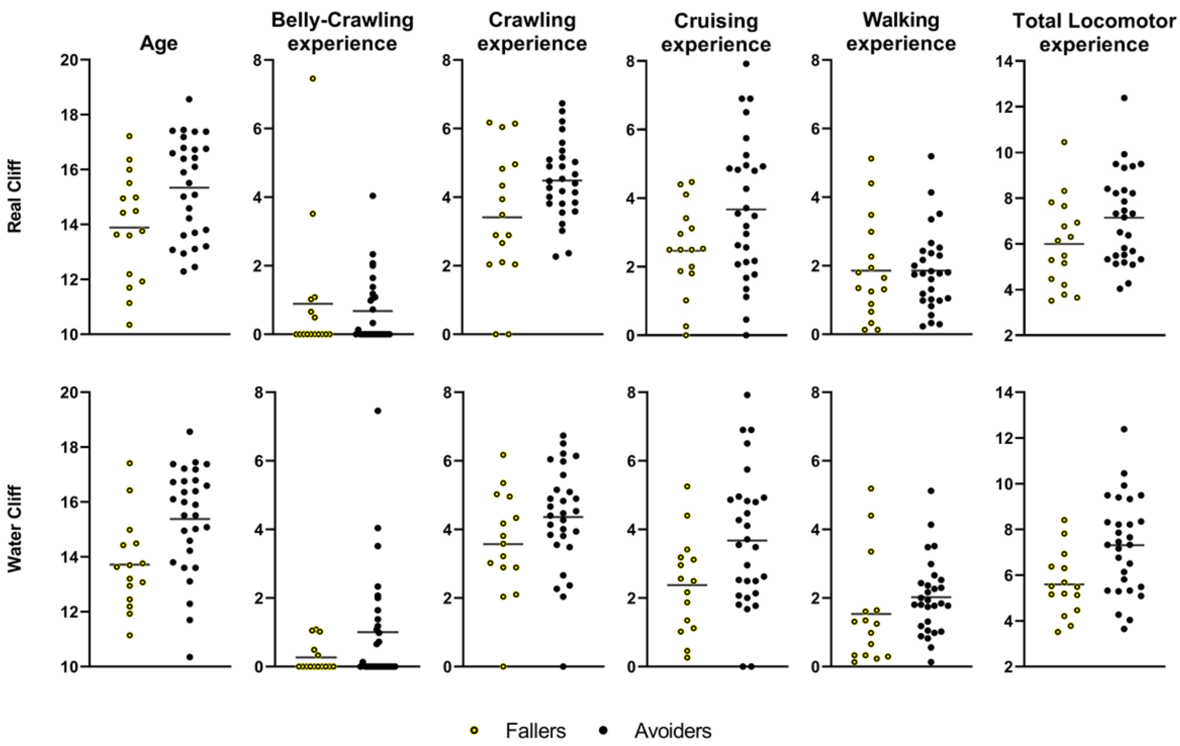

A positive but week correlation was found between age and crawling experience ($r(42) = .37$, $p = .013$), a positive and moderate correlation was found between age and cruising experience ($r(42) = .40$, $p = .006$) and between crawling and cruising experiences ($r(42) = .52$, $p < .001$), and a positive and strong correlation between age and walking experience (r(42) = .70, $p < .001$), age and total self-produced locomotor experience (r(42) = .71, $p < .001$), crawling and total self-produced locomotor experiences ($r(42) = .70$, $p < .001$), and between cruising and total self-produced locomotor experiences ($r(42) = .60$, $p < .001$). Assumption of collinearity tests indicated that multicollinearity was not a concern (all VIF values < 6).

In the real cliff condition, logistic regression models showed a significant effect of age ($\chi^2(1) = 5.01$, $p = .025$) and crawling experience ($\chi^2(1) = 4.35$, $p = .037$) on the

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likelihood that walkers avoided falling on the real cliff. The model with a single variable with lowest AIC score is the one with age (Table 3). The overall AIC-best model was an additive model with age and crawling experience as predictors. Therefore, the model with age and crawling combined is the one that best predicts the odds of walkers' avoidance of falling on the real cliff ($\chi^2(2) = 8.21$, $p = .017$), explaining 23% of the variance (Nagelkerke R^2) and correctly classifying 73% of cases.

TABLE 3 | AIC scores for logistic regression models for walking infants' avoidance behaviour on the real and the water cliff.

Real Cliff			Water Cliff		
	AIC	Delta AIC		AIC	Delta AIC
Age	55.91	0.43	Age	53.03	0.74
Belly-crawling experience	61.45	5.97	Belly-crawling experience	56.21	3.92
Crawling experience (Ce)	56.53	1.05	Crawling experience	57.84	5.55
Cruising experience (Cru.e)	57.21	1.73	Cruising experience	55.33	3.04
Walking experience	61.68	6.20	Walking experience	58.93	6.64
Self-produced Loc. exp. (SLe)	58.15	2.67	Self-produced Loc. exp.	52.29	0
			Age + SLe + Cru.e†	54.36	2.07
Age + Ce†‡	55.48	0	Age + SLe‡	53.35	1.06

† Model including variables with significant effect on the likelihood that walkers avoid falling.
‡ Model including variables with lowest AIC values when analysed alone.

The estimated odds of not falling on the real cliff are 1.38 times higher when age is increased by 1 month and crawling experience is held fixed; 95% confidence interval (0.95, 2.02) (see Figure 6.A) and 1.46 times higher when crawling experience is increased by 1 month and age is held fixed; 95% confidence interval (0.87, 2.42) (see Figure 6.B). Although the logistic regression model including cruising experience alone

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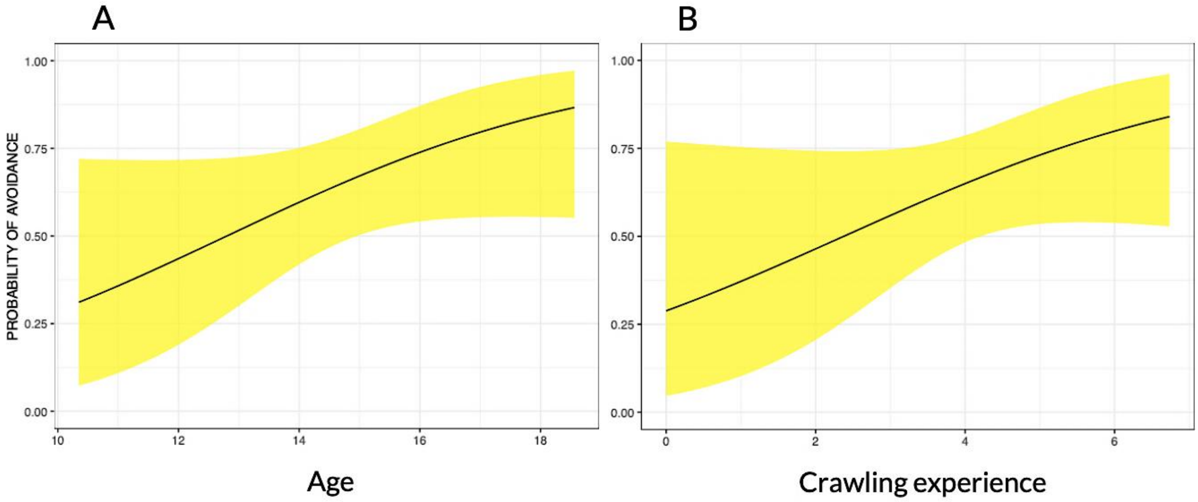
was not significant ($\chi^2(1) = 3.79$, $p = .052$) using an alpha level of $p < 0.05$ to reject the null hypothesis, the AIC value was within 2 units of the AIC-best model.

FIGURE 6 | The fitted AIC-best logistic model for walkers' avoidance of the real cliff. The plots represent the effect of age on probability of avoidance with crawling experience set to the mean value of 4.09 months (A) and the effect of crawling experience on probability of avoidance with age set to the mean value of 14.82 months (B). In both plots the solid black line gives the fitted value with 95% confidence interval in yellow.



On the water cliff, logistic regression models with age ($\chi^2(1) = 6.13$, $p = .013$), cruising ($\chi^2(1) = 4.22$, $p = .040$) and total self-produced locomotor experiences ($\chi^2(1) = 6.16$, $p = .013$) were significantly associated with walkers' avoidance behaviour. The model that best represents the set of data on the odds of walking infants' avoidance off falling is the one with total self-produced locomotor experience (Table 3). The model explains 24% of the variance in avoidance behaviour (Nagelkerke R^2) and correctly classifies 71% of cases, estimating that the odds of walking infants not falling on the water cliff are 1.72 times higher for each increased month of total self-produced

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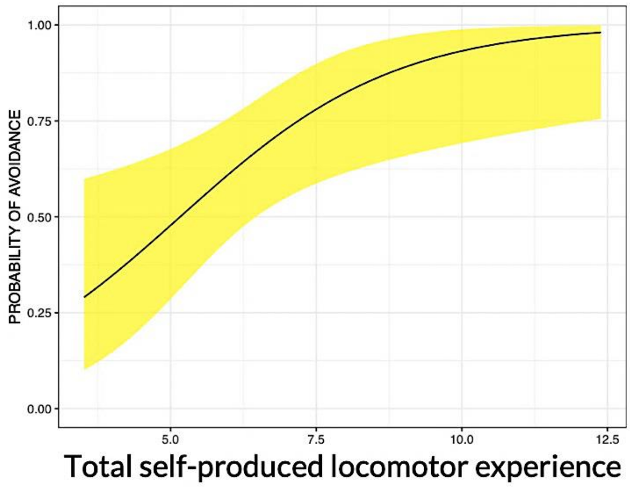
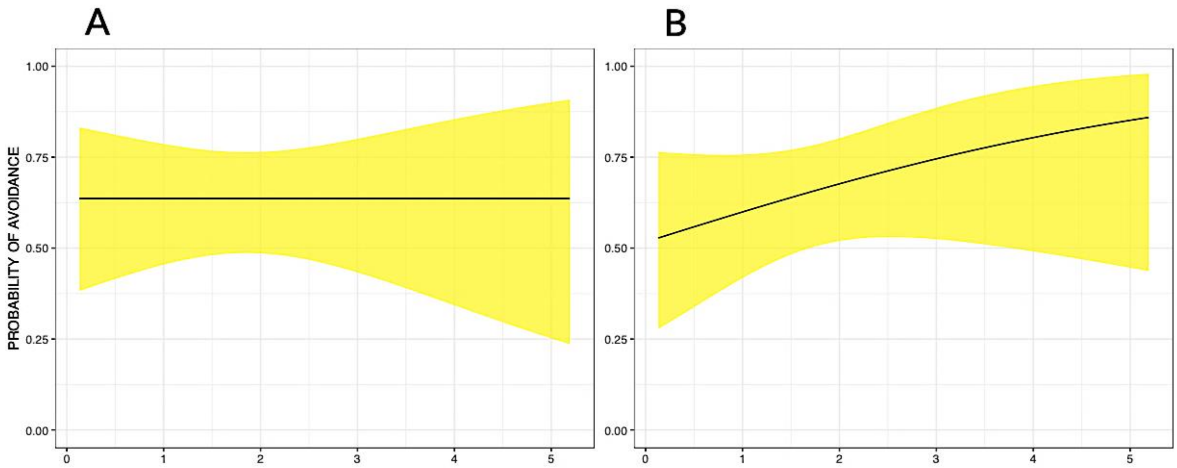
locomotor experience, 95% confidence interval (1.12, 2.64) (see Figure 7). The models with age alone and age combined with total self-produced locomotor experience cannot be dismissed.

FIGURE 7 | The fitted AIC-best logistic model for walkers' avoidance of the water cliff with crawling experience (in months) as predictor. The solid black line gives the fitted value with 95% confidence interval in yellow.



The logistic regression models including walking experience (see Figure 8) were not significant, indicating no effect of walking experience on the likelihood that walkers avoid falling on the real cliff ($\chi^2(1) = 0.00$, $p = 1.000$) and on the water cliff ($\chi^2(1) = 1.39$, $p = .238$). In fact, on the real cliff, mean values of walking experience were the same for avoiding and falling walkers (1.86 months). There was also no significant difference in the amount of walking experience between walkers who fell (M = 1.54 months, SD = 1.56) and those who avoided falling (M = 2.02 months, SD = 1.09) on the water cliff, *Welch's F* (1, 21.30) = 1.144, p = .297. AIC scores confirmed that there is little support for models that include walking experience (see Table 3).

FIGURE 8 | Logistic model with walking experience (in months) as predictor for walkers' avoidance of falling on the real cliff (A) and on the water cliff (B). The solid black line gives the fitted value with 95% confidence interval in yellow.



Approaching time - In the real cliff condition, three walking infants (one faller and two avoiders) did not move from the starting position within the first 60 s of testing and were placed on the edge by the experimenter. Approaching times for those walking infants were coded as missing. The time walkers took to approach the real cliff (M = 21.85 s, SD = 30.12) was not significantly different from the time they took to approach the water cliff's edge (M = 17.67 s, SD = 22.00), Z = 0.583, p = .560. There were also no significant differences in the approaching time between falling (M = 11.39 s, SD = 12.55) and avoiding (M = 27.89 s, SD = 35.49) walkers on the real cliff (U = 149, p = .213) nor between fallers (M = 13.38 s, SD = 15.09) and avoiders (M = 19.89 s, SD = 24.79) on the water cliff, U = 181, p = .366.

Latency time - Three of the 28 real cliff avoiders did not complete the 150 s of the trial after getting to the edge due to compulsive crying. Latency time for those walkers was 85 s, 86 s and 124 s. Statistically, there was no significant difference in latency time between the real cliff (M = 40.00 s, SD = 39.32) and the water cliff (M = 14.03 s, SD = 18.00) for falling walkers, Z = -0.070, p = .944.

Tactile exploration time – In the real cliff condition, nine avoiding and five falling walkers never engaged in tactile exploration. In the water cliff condition, one avoider and eight fallers never touched the water. The eight fallers that never engaged in tactile exploration of the water got to the edge and fell in under 4 s. Two additional fallers engaged in less than 1 s of tactile exploration of the water and fell less than 5 s after getting to the edge. Walkers' tactile exploration was not significantly different between the real cliff (M = 22.00%, SD = 26.64) and the water cliff (M = 28.38%, SD = 24.98), Z = -1.282, p = .200. There was also no significant difference in tactile exploration between fallers (M = 19.17%, SD = 25.59) and avoiders (M = 23.61%, SD = 27.55) on the real cliff (U = 207.5, p = .682). In the water cliff condition, avoiding walkers engaged in significantly more tactile exploration (M = 34.40%, SD = 22.87) than fallers (M = 16.72%, SD = 25.48), U = 105, p = .005. There was no significant difference in tactile exploration between fallers on the real cliff (M = 19.17%, SD = 25.59) and on the water cliff (M = 16.72, SD = 25.48), U = 105, p = .538. However, walking avoiders spent more time engaging in tactile exploration on the water cliff (M = 23.61%, SD = 27.55) than on the real cliff (M = 34.40%, SD = 22.87), U = 279.5, p = .043.

Posture of exploration – No significant difference in the percentage of latency time walkers spent in a sitting (RC: M = 11%, SD = 21; WC: M = 21%, SD = 31), quadrupedal (RC: M = 17%, SD = 26; WC: M = 12%, SD = 24) or upright posture (RC: M = 54%, SD = 41; WC: M = 52%, SD = 39) between the real and the water cliff was found. No walker ever adopted the lying prone posture to explore the water cliff, while eight did so on the real cliff condition. All the eight walkers that adopted a lying prone posture to explore the real cliff ended up avoiding the fall. More walkers adopted the squatting posture while exploring the water cliff (N = 20) than the real cliff (N = 7) and the percentage of latency time they spent in a squatting position was also greater on the water cliff (M = 9%, SD = 16) than on the real cliff (M = 5%, SD = 15), Z = -2.950, *p* = .003. Regarding the differences in percentage of latency time spent in different exploratory postures between the fallers and avoiders, there was no significant difference in the time spent in a sitting (fallers: M = 8.5%, SD = 19.5; avoiders: M = 12%, SD = 22), quadrupedal (fallers: M = 15%, SD = 30; avoiders: M = 17%, SD = 24), squatting (fallers: M = 9%, SD = 20; avoiders: M = 2%, SD = 10) or upright posture (fallers: M = 64%, SD = 40; avoiders: M = 49%, SD = 41) while exploring the real cliff. In the water cliff condition, no faller ever sat down while 21 avoiders adopted a sitting posture (M = 32%, SD = 34). There were no significant differences in time spent in a quadrupedal posture (fallers: M = 8%, SD = 24; avoiders: M = 13%, SD = 24) or squatting posture (fallers: M = 7%, SD = 17; avoiders: M = 11%, SD = 16). However,

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fallers spent significantly more time (M = 83%, SD = 35) than avoiders (M = 37%, SD = 31) exploring the water cliff in an upright posture, U = 79, p = .001.

Falling posture - Nine of the 16 walking infants that fell on the real cliff (56%) and 12 of the 15 water cliff fallers (80%) fell while adopting an upright posture. On the real cliff, three walkers fell while sitting, two while squatting and two fell from a quadrupedal posture. On the water cliff, two walkers fell from a quadrupedal posture and one while squatting.

Retreat behaviour - The number of walkers that retreated from the edges was not significantly different between the real cliff (39%) and the water cliff (27%) (p = .359, McNemar's test). In the real cliff condition, there was no significant difference in the proportion of fallers (31%) and avoiders (43%) who moved away from the edge, $\chi(1)$ = 0.579, p = .447. However, on the water cliff, avoiders moved away from the edge (40%) significantly more than fallers (7%), $\chi(1)$ = 4.872, p = .027.

Crawlers vs. Walkers

There were no significant differences in the proportion of crawlers (31%) and walkers (36%) that fell on the real cliff, nor in the proportion of crawlers (28%) and walkers (34%) that fell on the water cliff. On the real cliff, avoiding crawlers had more crawling experience than avoiding walkers had walking experience (see Table 1), *Welch's F* (1, 65.70) = 4.474, p = .038. On the water cliff condition, although avoiding

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crawlers had more crawling experience than avoiding walkers had walking experience (see Table 1), the difference was not significant, *Welch's F* (1, 68.02) = 1.901, p = .172.

DISCUSSION

This study investigated the effect of age and specific locomotor experiences on infants' ability to perceive the risk and adapt their behaviour to safely navigate a real and water drop-off.

Infants' avoidance behaviour and the posture-specific affordance learning hypothesis

These current results confirmed those of Burnay and Cordovil (2016), linking crawling experience to crawlers' avoidance behaviour on the real and the water cliff. Although strongly correlated, crawling experience and total self-produced locomotor experience alone were the best predictors of the odds of crawlers' avoidance of falling on the water and the real cliff, respectively. Belly-crawling alone had no effect on crawling infants' avoidance of either cliff. However, when belly-crawling was added to the hands-and-knees crawling experience the odds of crawlers avoiding falling on the real cliff increased.

These results are also in line with previous studies showing that avoidance of visual cliffs (e.g., Bertenthal & Campos, 1984; Campos et al., 1992; Ueno, Uchiyama, Campos, Dahl, & Anderson, 2012) and drop-offs (Adolph, 1997; 2000; Kretch & Adolph, 2013) becomes more probable after weeks of crawling experience. Through crawling experience, infants learn to appreciate the meaning in the information they pick up and to distinguish between surfaces that afford from those that do not afford locomotion. Experienced crawlers educate their attention, or become attuned, to the relevant information in the environment that specifies the affordances for locomotion, and they learn how to scale, or calibrate, their own action capabilities to the information offered by the surface of support (see van Andel, Cole, & Pepping, 2017).

For walkers, age and self-produced locomotor experience increased the odds of not falling on both cliffs and crawling experience increased the odds of avoidance of falling on the real cliff. Surprisingly, although walking experience was strongly correlated with age and moderately correlated with total self-produced locomotor experience, the increase in walking experience had no effect on walkers' avoidance behaviour on either cliff. The Sway Model proposed by Adolph (2000) and the posture-specificity hypothesis (see Adolph, 2019) suggests that to behave adaptively on drop-offs, crawling infants need weeks of crawling experience and walking infants need weeks of walking experience, with no transfer of what is learned between locomotor postures. However, the findings of the present study do not support the idea that when infants start walking, they need weeks of walking experience to avoid falling from cliffs. Instead, walking infants who had more crawling and total self-produced locomotor experience showed more adaptive behaviours. These results are consistent with the idea that there is some degree of "learning how to learn" (see Adolph, 2005) across what have been considered modularized systems of postural control and that what

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infants learned while crawling makes a positive contribution to behaving adaptively in the walking posture.

Kretch and Adolph (2013) reported that none of their experienced crawlers attempted to crawl over a 90 cm height drop-off while 63% of the new walkers did so. As our results show no association between walking experience and walkers' avoidance behaviour, there is evidence that although transferable between action capabilities, perceptual-motor calibration is a dynamical and ongoing process that needs to be tuned when a new action capability emerges (see Withagen & Michaels, 2002). It seems that, by exploring the environment in a crawling locomotor posture, infants become capable of perceiving the affordance and adapting their behaviour to safely navigate drop-offs. When the walking skill emerges, instead of needing to relearn all over again how to adapt their behaviours around drop-offs, infants need to recalibrate the perceptual information according to their new action capability. Much as experienced athletes can recalibrate to variations in tasks and the environment more rapidly than less experienced athletes (Seifert, Button, & Davids, 2013), experienced crawlers seem able to recalibrate their behaviour to the new walking skill faster than infants with less previous crawling experience.

Posture of exploration

Crawlers who fell did so mostly while adopting a crawling posture and they explored the setting adopting primarily the crawling posture, while avoiders explored more from a sitting posture, on both cliffs. For the walkers, real cliff fallers and avoiders did not differ in the exploratory postures adopted whereas, on the water cliff, fallers

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spent more time in an upright posture than avoiders. The fact that infants who fell more frequently adopted the last acquired locomotor posture and those who avoided adopted a more experienced one could be interpreted as evidence that while adopting a new locomotor solution, infants are less capable of perceiving the affordances of the environment and of adapting their behaviour accordingly. However, because the infants were free to explore the settings and adopt any exploratory posture they decided, this argument would be circular. It is unclear whether the infants sat down, adopting a more experienced posture of exploration, because they perceived the affordance of the drop-off and avoided the fall, or whether they perceived the affordance, and then decided not to go over the edge and sat down.

Exploratory behaviours

To developing infants, a drop-off (filled with air) and a body of still water may be difficult to distinguish visually. Hence, mothers were instructed to touch and move the water, thus offering the infants visual information of a water surface, which does not occur on the real cliff. Therefore, the information provided by the two cliffs were haptically and visually different. Yet, the great majority of infants showed the same avoidance behaviour on both cliffs. These results confirm those of Burnay and Cordovil's (206), indicating that infants perceive the non-supportable affordance of a body of water and a drop-off similarly.

When comparing infants' behaviour on rigid plywood versus a deformable waterbed, both setups 'enabling' locomotion, E. J. Gibson et al. (1987) reported similar exploratory and avoidance behaviours. Likewise, when comparing infants' behaviour between the real cliff and the water cliff (both 'preventers' of locomotion) infants (both crawlers and walkers) took similar amounts of time to approach either cliff, the adopted posture of exploration did not differ between cliffs and, for those who fell, they did not fall faster on one or the other cliff. These results provided further evidence of infants' similar perception of the non-supportive affordance of the real and the water cliff.

Interestingly some exploratory behaviours provide evidence of a greater attraction to bodies of water than dryland drop-offs. For instance, crawlers engaged in more tactile exploration on the water cliff than the real cliff and retreated more from the edge of the real cliff than from the edge of the water cliff. In addition, whereas on the real cliff fallers and avoiders engaged in similar tactile exploration, on the water cliff, even the infants (crawlers and walkers) who avoided the fall stood near the water playing with it, consequently enhancing the risk of an accidental fall. This greater attraction to bodies of water may help to explain the higher vulnerability of infants to experience fatal drowning incidents from unanticipated immersion than to experience falling incidents (Peden et al., 2009).

CONCLUSIONS

The current study suggests that infants perceive the non-supportive affordance of real and water drop-offs similarly and, although their behaviour may be more dangerous around bodies of water, they avoid both cliffs similarly. Crawling and total self-produced locomotor experiences informed not only crawling but also walking infants' adaptive behaviour. Importantly, walking experience alone had no effect on walkers' avoidance of falling from cliffs, filled with water or not. These outcomes refute the idea that infants' behaviour at a drop-off is learned in a posture-specific way and that no transfer occurs when a new locomotor skill emerges. Instead, these findings indicate that through weeks of crawling experience, infants learn to perceive affordances for locomotion and this learning informs their behaviour in the walking posture.

The evidence for transfer is strong but not yet strong enough to provide insight into the degree of transfer. Because the research design was cross-sectional, it is impossible to know whether new walkers who were classified as "fallers" would have been classified as "avoiders" if they had also been tested as experienced crawlers. A longitudinal study is required to clarify whether experienced crawlers who avoid falling from cliffs continue to avoid falling when they become new walkers.

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