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An Experimental Study of Persuasive Design's Effects on Children's In-App Choices and Play

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Abstract

Persuasive digital design features pervade apps for children, yet there is little causal evidence of their individual, cumulative, and interacting effects. This constrains scientific certainty and policy action. Using a purpose-built app, this study varied persuasive design elements while keeping gameplay otherwise constant. 554 children (Mage=4.34 years) were randomly assigned to one of five conditions, from no persuasive design to all persuasive design features combined (character pressure, locked options, pop-up advertisements). Children were significantly more likely to follow a character's recommendation, yet they avoided locked options at greater-than-chance levels. Still a majority attempted to access at least one locked item and bypass parental controls. When combined, deterring effects of locked content outweighed character persuasion. Effects of advertising were varied: almost half attempted to purchase a limited-time character, yet most closed an advertisement before its completion. This offers important causal evidence that effects of persuasive design vary by feature and context.

Introduction

Children's digital engagement no longer unfolds solely according to their preferences and interests. Instead, and increasingly, their digital activity is shaped by in-built digital design features that prolong their engagement, influence their choices, encourage them to invest their resources, and, after their digital activity has ended, hasten their return. These persuasive digital design features–also referred to as deceptive design and dark patterns (Brignull et al., 2010)–take many forms. Examples include, but are not limited to (Gray et al., 2024): parasocial character pressure, wherein a trusted character exploits their parasocial relationship with the child to motivate a particular in-app choice; pay-to-play, where locked content requires investment of time or money to access; advertising, both of products related to and external to the gameplay; rewards for longer play; auto-play that immediately starts the next game at the end of the last, removing friction to continue playing; pressured selling, including limited-time and bundled offers; and disguised ads masquerading as a normal aspect of gameplay. What these persuasive design features have in common is that they use psychological principles to guide users toward certain behaviours and choices often without consideration of, and in opposition to, a child's interests.

The mechanisms by which persuasive design elements are theorised to exert these effects, overwhelming or subverting efforts and opportunities to resist them, are diverse. For instance, Fogg's (2009) Behaviour Design Model proposes that for behaviour to occur there must be concurrent motivation to act, sufficient ability or ease to act, and some call to action. A behaviour is increasingly likely at higher levels of motivation and/or lower levels of difficulty or friction. In digital design, this is operationalised by increasing motivators (e.g., immediate gratification, apparent high-value offers, salience of stimuli) and decreasing barriers to action (e.g., reducing options and sources of friction impeding their selection), which is supplemented by lures that capture attention and encourage immediate behaviour. Other explanations point to effects of persuasive design on users': physiological reactivity, such as excitement or frustration overwhelming capacity for reasoned, goal-directed behaviour; dual process thinking, where fast or intuitive decisions are encouraged before slower, analytical thinking can occur that would be less favourable to the persuaded behaviour; social affinities, whereby para/social conditions are established that make users feel more or less compelled to act; attention, leveraging lures to alert, orient, and sustain attention; response tendencies, using reinforcement to make a desired behaviour increasingly more likely; and, relatedly, willingness to take risks (Chang et al., 2024). Indeed, one scoping review found 18 different theories employed to explain the mechanisms and pathways of persuasive design's effects on users' behaviours (Chang et al., 2024).

Research establishes that these persuasive design features are pervasive, even among digital products designed for young children. For instance, a large content review of 160 top-ranked apps for young children (aged 3+ years) found

that 83.8% had at least one of the eight persuasive design features evaluated (Radesky et al., 2022). The most common persuasive design features were navigation constraints (in 70.6% of the apps), attractive lures (in 66.9% of the apps), parasocial pressure (in 26.3% of the apps), and time pressure (in 18.8% of the apps). Another content review found that >99% of the 132 apps reviewed had at least some element that promoted continued engagement, and 85% used persuasive design to nudge users toward persuaded behaviours, reduce user friction toward those behaviours, *and* increase user's motivation to pursue those behaviours (Mallawaarachchi et al., 2023). They also found little difference in the prevalence of most persuasive design types between free and paid apps (except that prompts to purchase were more prevalent in free apps) and between apps with and without 'Teacher Approval' (except ads and fear-based motivators were less common in Teacher-Approved apps). In a study of German-language children's apps, all 20 of the reviewed apps contained some form of attempt at user manipulation, despite EU frameworks and protection legislation aiming to prevent this (Krahl et al., 2025). A content review of 20 top-ranked apps for children found as many as six different forms of persuasive design within a single app (in three of the 20 reviewed apps) (O'Donnell et al., 2026), with high levels of disguised ads (in 65% of the apps), pay-to-play (in 80% of the free apps and none of the paid apps), and visual prominence (in 70% of the free apps and none of the paid apps). Also, Radesky et al. (2022) find a socioeconomic gradient in exposure to persuasive design, with more persuasive design features encountered by children in households with lower income and whose parents have lower levels of education.

Although persuasive design features are widely accepted to influence users' choices and experiences, evidence of their specific and cumulative impacts remains scarce–or, at least, exists as developers' commercial-in-confidence proprietary data that are not available for public scrutiny. Questions thus remain: What features are persuasive, and what precisely do they persuade? What are the individual, relative, and cumulative impacts of persuasive design features? Who do they persuade, and under what conditions? Answers to these questions are important for several reasons. First, this would provide evidence of consequential targets for government regulation and legislation (e.g., digital duty of care), advancing children's rights (Livingstone et al., 2025) and safety-by-design approaches (eSafety Office of the e-Safety Commissioner, 2019). Second, and given the slow pace of this legislation internationally, understanding the mechanisms and conditions of effect could help inform parallel approaches and strategies to support children and families to recognise, understand, and become more resistant to effects of persuasive design (as called for in Darin & Carneiro, 2025). Intervention studies show initial promise in this regard (Babaei & Vassileva, 2025; Helamo, 2023; Khan et al., 2025; Lu et al., 2024). Third, if and where children already appear resilient to specific forms of persuasive design, this would provide evidence that resistance can be cultivated and point to avenues of investigation into how this 'inoculation' was achieved. This could be instructive for future and further education and intervention efforts toward beneficial content and contexts of children's digital activities, while protecting children from digital risks and harms.

However a recent study investigating the effects of persuasive design illustrates a challenge in pursuing these answers (Mallawaarachchi et al., 2025). In that study, the researchers selected three high-ranked commercially available apps that were high, moderate, or low in persuasive design (as characterised by a prior content analysis). These apps had a common wireframe and gameplay theme, in which the child playfully interacts with and cares for an animal friend. Children were given 7 minutes to play with their assigned app and results showed that, at high levels of persuasive design, a subgroup of children played significantly longer than instructed and they required greater adult support to transition away from the play. This aligns with accounts that persuasive design extends engagement and makes stopping more difficult. Yet ascribing this to persuasive design is complicated by the fact that commercially available apps differ not only in level of persuasive design, but also in the types and timings of persuasive design and other aspects fundamental to play (e.g., character, gameplay, functionality, background). It is

also unclear whether and how persuasive design features impacted children's in-app behaviours. More-causal claims require an ability to manipulate persuasive design features (i.e., their type, location, frequency, pattern) while holding constant all other aspects of the game.

In this study we pursued a unique innovation: developing and implementing an app-based game for children that allows safe manipulation of persuasive design features–individually and in combination–while holding constant surrounding gameplay. Paradigms like this potentiate more-causal evidence of the relative, comparative, and cumulative effects of persuasive design, and whether, how, to what extent, and for whom these features are 'persuasive'. Given a pervasive belief and mounting evidence that persuasive design is indeed genuinely compelling, we expected that children would tend to be persuaded by most of the persuasive design features they encountered (e.g., character pressure, limited time offers), and that their impacts would increase if persuasive design features were layered atop one another. However, we also expected variability in this: not all children would pursue persuaded options and, given high levels of parental intervention on children's digital purchases in particular (Ofcom, 2025; Video Games Europe, 2024), that children would tend to avoid pay-to-play locked options. This study presents findings of the isolated and cumulative effects of persuasive design, directly on young children's in-app choices and indirectly on their surrounding app play.

Results

Overall App Engagement

Children (*N* = 554) played with a purpose-built story-making app in which persuasive design features could be experimentally controlled while gameplay remained otherwise constant. Across five conditions, children encountered no persuasive design, character pressure, pay-to-access locked options, both features combined, or all persuasive design features together (added pop-up advertisements). Primary outcomes were whether children selected persuaded or locked options, attempted purchases, and completed stories. Secondary outcomes included total stories created and play duration. Participating children created 1,176 stories, averaging 2.12 stories per child (*Mdn* = 1, *SD* = 2.18, range = 1-21). Just over half of the children (*n* = 279) completed at least one story. Forty-one percent of the children (*n* = 227) completed more than one story. Nine percent (*n* = 51) created 5 or more stories. On average children played for 6.83 minutes (*SD* = 5.03 min, range = 0.09 to 44.68 min), and even children who did not complete their story played on average >6 minutes before disengaging (typically on or after the colouring screen, where children spent a majority of their play time). Children randomly self-selected themselves into conditions as follows: active control (*n* = 134): character pressure only (*n* = 129); pay-to-access locked options only (*n* = 102); a condition combining 2 and 3 (*n* = 63); and all persuasive design features active (*n* = 126).

Susceptibility to Persuasive Design Analyses

Initial analyses sought to evaluate whether children's engagement with persuasive design elements differed significantly from chance (12.5% for character pressure; 50% for locked options) and full avoidance (0).

Character Pressure

In the condition in which children were presented with character pressure only, 26% of the children selected the pressured character, while 19% selected the pressured background for their story. Eight character and background options were available, with the persuaded option randomly assigned among them, yielding a chance selection probability of 12.5%. A chi-square goodness-of-fit test showed that children were significantly *more likely* to choose the persuaded option than would be expected by chance: character selection, $X^2(1, N = 129) = 22.65$, $p < .001$; and

background selection, $X^2(1, N = 128) = 4.57$, $p = .033$. If choices were unaffected by persuasion, the recommended option would be expected to be selected on approximately 12.5% of occasions. However, children were twice as likely to select a persuaded character and 1.5 times more likely to select a persuaded background.

Pay-to-Access Locked Options

In the condition in which children were presented only with pay-to-access locked options (items requiring a simulated purchase process to access), half of the character and half of the background options were locked. Twenty-two percent of children selected a locked character and 15% of children selected a locked background. When selecting a voice filter, 9% opted for a locked item. Because half of the available options were locked, chance selection of a locked item was 50%. A chi-square goodness-of-fit test showed that in all cases children were significantly *less likely* than chance (50%) to select a locked option: character selection, $X^2(1, N = 102) = 32.98$, $p < .001$; background selection, $X^2(1, N = 101) = 49.90$, $p < .001$; and story voice filter selection, $X^2(1, N = 32) = 21.13$, $p < .001$. However, children also interacted with locked options significantly more than complete non-engagement (i.e., 0), as indicated by the 95% CI not including 0: locked character selection, $n = 22$ of 102, 95% CI [.15, .31]; locked background selection, $n = 15$ of 101, 95% CI [.09, .23]; and locked voice filters, $n = 3$ of 32, 95% CI [.03, .24].

Yet, in total, 63 children (62%) in this condition selected at least one locked option and attempted the parental verification screen. Over half of these children managed to bypass the parental verification ($n = 35$, 55.6% of children who attempted it). The average number of child attempts to bypass the parental verification screen was 3.12 ($SD = 3.79$), ranging from 1 to 26 attempts. While the parental verification screen was designed to have low requisite knowledge, or to be bypassed with a low number of random attempts, it mirrored an authentic parental verification screen encountered in a review of top charting apps for children (O'Donnell et al., 2026).

Character Persuasion of Locked and Unlocked Options

In the condition that presented both character persuasion and pay-to-pay locked options concurrently, the main character randomly suggested one of the locked characters options and an unlocked background (Figure 1).

Character Selection

A chi-square goodness-of-fit test showed that children selected the pressured locked character lower than chance (12.5%), $n = 2$, 3.3%, $X^2(1, N = 63) = 5.01$, $p = .025$. Comparing the probability of selecting a persuaded locked character (in the character pressure + pay-to-play locked option condition) and a persuaded unlocked character (in the character pressure only condition), a chi-square test of independence showed children selected an unlocked pressured character more often than when the pressured character was locked, $X^2(1, N = 192) = 14.93$, $p < .001$.

Background Selection

In the character pressure + pay-to-play locked option condition, children selected the pressured unlocked background higher than chance ($n = 20$, 32.8%), $X^2(1, N = 61) = 22.95$, $p < .001$, but non-significantly more than chance when considering only unlocked options (25%), $X^2(1, N = 61) = 1.97$, $p = .160$. Comparing the probability of selecting a pressured unlocked background that is either surrounded by locked options (in character pressure + pay-to-play locked option condition) or not (in the character pressure only condition), children chose at a higher rate the pressured background when it was surrounded by locked options, $X^2(1, N = 189) = 4.56$, $p = .033$, even though in both cases the pressured item was unlocked.

Pop-up Advertisements

Children in the condition with all persuasive design features active encountered an additional limited-time character offer before character selection and a pop-up advertisement for a fictional external product before accessing their completed story.

Of the children in this condition, 58 children (46%) attempted to purchase the limited time character. This was significantly higher than complete non-engagement, *n* = 58 of 126, 95% CI [.38, .55] (because the 95% CI did not include 0). Twenty children (16%) successfully purchased the limited time character by successfully bypassing parental verification.

Of the children in this condition that reached the voice narration screen (after which a pop-up ad for an imaginary product was played), 65% (*n* = 28) closed the pop-up ad before it finished. Fifteen children (21%) attempted to purchase the imaginary product by interacting with the pop-up ad, and six (14%) successfully bypassed the parental verification process. On average, children viewed the 34-second pop-up ad for 25.14 seconds (*SD* = 29.30, range = 1.17 to 103.53s).

A summary plot of the probability of children's engagement with each design feature, relative to chance, is provided in Figure 2.

Effect of Persuasive Design on Gameplay Duration

A summary of app play metrics (i.e., play time and number of stories) for all participating children, by condition, is provided in Table 1. A one-way ANOVA evaluating the effect of condition on the number of stories created showed a small but significant effect of persuasive design condition, $F(4, 549) = 2.60$, $p = .036$, partial $\eta^2 = .019$. Post hoc analysis revealed that children in the character pressure condition created more stories (*M* = 2.52, *SD* = 2.68) than all the other conditions with one or more forms of persuasive design (*M*s £ 2.01). The number of stories created by children in the character pressure condition was non-significantly but descriptively higher than in the condition with no persuasive design (*M* = 2.16, *S*D = 2.00).

A chi-square analysis of the rate of completing at least one story was also significantly different between conditions, $c^2(4) = 10.48$, $p = .033$. There were lower rates of completion than expected in the condition with all persuasive design elements present (expected = 40.7, observed = 27), and non-significantly but descriptively higher rates of completion in Character Pressure (expected = 41.7, observed = 49) and Character Pressure with Locked Options conditions (expected = 20.4, observed = 25).

A one-way ANOVA evaluating effect of condition on natural log-transformed total play time (to correct for strong positive skew) was conducted for those who completed a story, given differential rates of non-completion and time to early exit. The effect of condition on play time for those who completed a story was non-significant, $F(4, 174) = 0.80$, $p = .528$, $\eta^2 = .02$. Descriptively, among children who completed a story, playtime was longest in the condition with pay-to-play locked options (*M* = 9.49 min, *SD* = 5.26) and shortest in the condition with character persuasion and pay-to-play locked options (*M* = 7.05 mins, *SD* = 3.21) – representing a 34.6% longer play time. The condition with no persuasive design showed the second longest mean play time (*M* = 8.76 min, *SD* = 7.40).

Discussion

The current study provides the strongest causal evidence to date for the nuanced effects of persuasive design. Rather than a uniform effect, the evaluated persuasive design elements exerted different independent and

cumulative impacts. Children were highly likely to be persuaded by parasocial pressure from a friendly in-app character–even though the child had no prior awareness or affinity with that character. Children exposed to character pressure also produced significantly more stories. Previous research finds that parasocial pressure is regularly used to encourage children to continue playing and expressing disappointment or impatience when play stops (Radesky et al., 2022). However, in the current app the character's actions (i.e., suggesting their preferred option) did not encourage prolonged play. It is possible parasocial pressure may also implicitly motivate longer play even in the absence of explicit encouragement. For instance, children may experience this as a sort of collaborative play alongside a character who is seemingly interested in what they do and choose (Calvert, 2017). While research is needed to evaluate this possibility, this account is consistent with trusted characters exerting affective pressures to continue playing (Krahl et al., 2025)–just, in this case, uniquely demonstrated in the absence of explicit persuasions to do so. This potential mechanism is consistent with research from the Computers as Social Actors paradigm, which shows a range of ways in which people automatically apply social rules and expectations (in this case, collaborative play) when interacting with computers (Sundar & Chen, 2023). Methods such as retrospective stimulated recall (MacKenzie et al., 2024) would enable important explorations into how children's reasoning contributed to their decisions and would be a useful inclusion in future research.

Yet the extent to which children were persuaded by parasocial pressure varied between decisions. Children better resisted the character's urging to select a specific background. While research establishes differences in children's understanding between types of deceptive design (Schäfer et al., 2025), insights into contextual variation in reactions to the same persuasive design feature is scarce. In the current study this phenomenon seemed less likely to be driven by stakes of the decision, in which case we might predict that children would be more resistant to suggestions for initial character selection and more persuaded by subsequent background suggestions. While our data cannot offer definitive reasons for this diminished influence, one possibility is that as the child's story idea became better crystallized (following character selection), they became less susceptible to adjusting their plan in response to unexplained urging of the app's character. This is conceptually consistent with what is described in adults as goal shielding (Shah et al., 2002), wherein commitment to a focal goal has an effect of shielding that goal from competing alternatives. Theory (e.g., Gollwitzer & Crosby, 2018) and meta-analyses (Breitwieser & Reinelt, 2026) also support the premise that implementation intentions improve goal attainment. Extrapolated to digital contexts, this implies potential benefits from establishing clear plans, purposes, goals, and/or implementation intentions preceding the digital activity.

Contrasting the influence of character pressure, children were less likely to be drawn by–though were not entirely impervious to–pay-to-play locked options. On a decision-by-decision basis, children chose locked options less frequently than chance, indicating their avoidance of these options more than if unlocked. This provides evidence that children can–and have begun to–learn to recognise and resist at least this form of persuasive design. Hardwick et al. (2025), using think aloud methods to understand children's experiences of game monetisation, found that young children (aged 7-13 years) were already demonstrating a sophisticated understanding of in-game monetisation attempts–identifying several of these as scams or tricks. A recent Ofcom report indicates UK parents are highly cognisant and proactive in monitoring and controlling children's digital spending, with 84% using some form of device-or app-level restrictions or notifications to enable oversight (Ofcom, 2025). While conversation with children about online spending was not explicitly asked in that survey, parent responses imply various forms of conversations with their children about this particular functionality (i.e., through argument, punishment, child becoming more careful in spending money). It thus may be that online spending is the subject of greater family conversation and child learning, and/or that friction caused by parent gating controls–thwarting child attempts to access locked options–has reduced children's tendency to pursue pay-to-play locked options. There is evidence that

teaching children about deceptive design can indeed lead to changed in-app behaviours–at least within the learned context (Khan et al., 2025).

Alternatively, or additionally, it may be that the setting for our research–a public space, in which they were using a device that did not belong to them (nor to a family member) in their parent's presence–influenced children's behaviour. They may have felt less confident or comfortable in exploring locked options than they might at home, on a device belonging to a family member. This possibility seems at least partially contradicted by the majority of children attempting a locked option at least once during gameplay. That is, a majority of children (62%) attempted to access at least one locked option at some point in the game and, when they did, they attempted to bypass parental verification an average of 3 times (and, for one child, 26 times). This shows that even if pay-to-access design features introduces friction to the gameplay, children will often entertain options to remove that friction from a desired option. While reports of adolescents spending concerning amounts of money on in-game purchases are widespread, cases in children as young as 5 years of age have also been identified (e.g., a child spending £300 before detection; Kleinman, 2019). While the scope and scale of this issue amongst young children is less clear, it is notable that nearly half of the >400 UK parents responding to a recent Ofcom (2025) survey indicated their 8-9-year-old had spent money whilst gaming in the last month. This is consistent with our game-level trend, wherein over half of the children attempted to access at least one locked option.

When parasocial pressure and locked options were combined, resistance to in-app locked options appeared to overpower parasocial pressure, with children tending to continue to resist pressured locked options. Indeed, for many children locked options seemed to narrow the range of considered options and made parasocial pressure even more compelling when an unlocked option was pressured in the context of other locked options. While there is little causal evidence of the effects of specific combinations of persuasive design elements, there is broad evidence of developers employing deceptive pattern "combos" (the layering of two or more deceptive design elements) and "enhancers" (layering of design elements that are not themselves deceptive, yet they serve to increase the impact of the deceptive pattern they are combined with) (Zhang et al., 2025). Findings support and add nuance showing cumulative but not simply additive effects if deceptive design features are "stacked" compared to their use in isolation (Luguri & Strahilevitz, 2021; Schaffner et al., 2026). Moreover, our findings suggest that this may not apply to all combinations of persuasive design elements.

Children also showed nuanced susceptibility to our in-app advertising. When given the opportunity to purchase a limited-time character at the outset, before gaining access to a default array of eight characters, nearly half of the children (46%) attempted to purchase it. Yet most children (65%) closed our later-appearing pop-up ad before its conclusion. Still, despite an ability to exit the ad as soon as it appeared, on average children viewed the ad for 25 seconds (of its 34-second duration) before closing it. Fifteen children (21%) attempted to purchase and download the fictional app. Livingstone and Helsper (2006) find that younger children are not necessarily more susceptible to advertising, but are differentially susceptible–e.g., to peripheral perceptual features of advertising over quality, claims of the advertising, and a product's value to their lives. While we did not manipulate the features of our advertisement (e.g., higher versus lower salience, information, and value proposition), our approach would enable research of this kind given expansions to the app. It would also enable causal evaluations of acute effects (i.e., actual purchase attempts), rather than reflective accounts of purchase intentions. Understanding these impacts is important given the prevalence of advertising to young children within digital products (Meyer et al., 2019) and evidence that children are more susceptible to modern digital advertising (e.g., advergames; Villanueva et al., 2016). It is also pertinent given the prevalence of blurring of content and advertising, e.g., via disguised adverts (O'Donnell et al., 2026).

Research is also needed to better understand children's perception and decision-making processes as they encounter different forms of persuasive design, their combination, and across contexts and modalities. Tools such as *Giggle Scribbles* offer a vehicle to generate evidence of this kind, while adhering to important responsibilities related to children's rights and interests, safety-by-design approaches, and ethical responsible research. We deliberated at length whether these findings could be exploited for less moral purposes, designing products that are increasingly persuasive to young children. While no researcher can control how their findings are repurposed, it was our determination that: (1) digital developers hold these sorts of data already, as commercial-in-confidence proprietary data, and routinely leverage their data-driven insights for commercial benefit; and (2) an important step toward empowering families to make beneficial digital choices and supporting their resilience to digital design tactics is to understand where and how persuasive design operate, and to identify plausible pathways and mechanisms to resistance. Indeed, this study points to several possible mechanisms through which children and families might build awareness, knowledge, and resilience to persuasive design–for example, through establishing clear plans and intentions prior to digital activity, conversations with children and oversight over a broader range of persuasive design elements, and curating digital options for children that consider the products' use of persuasive design.

Indeed, our aim in developing and researching *Giggle Scribbles* was to understand in greater nuance the effects of persuasive design on children's gameplay, to then leverage these insights to support children and families to resist persuasions contrary to their preferences and interests. This is an area for urgent attention and action. Even if government regulation catches up with the pace of technological innovation, the best-case scenario seems to be that children's digital activity and associated outcomes will be a shared responsibility between government, developers, and families. Supporting families to curate beneficial digital experiences for their children, which support positive family outcomes and help prepare children to meet the digital demands in their future, will remain a priority. A review of interventions points to low efficacy of existing approaches to support users' resistance to deceptive design (Schaffner et al., 2026)–perhaps due to their separation from the gameplay itself (e.g., "cool down" periods, teaching them about deceptive patterns and their consequences more generally). Here too there is novel potential for approaches like *Giggle Scribbles*, to embed learning, strategy, and practice within the gameplay. This educative potential is important, offering a novel vehicle and resource for instigating and facilitating conversations about persuasive design between adults and children. It remains an outstanding question whether this might be a more effective means of behaviour change and, if so, whether effects generalise to gameplay more widely.

By virtue of pursuing children's self-selected and naturalistic in-app play, at the expense of more expansive surrounding data collection, the current study is unable to explore further the question of individual differences in children's susceptibility to persuasive design. Factors such as self-regulation have been shown to be likely protective factors against at least some impacts of persuasive design (Mallawaarachchi et al., 2025), although this requires replication and deeper investigation. Moreover, our methodology likely had the undesirable consequence of excluding important population subgroups, such as children whose parents are more digitally resistant and did not permit their child's app play (although, even upon invitation we might expect such families to decline). The skew toward higher socioeconomic advantage amongst the children's museum members is likely also influential, although this may have depressed the size of our effects given evidence that children in disadvantaged households are exposed to higher levels of persuasive design (Radesky et al., 2022). Research should explore whether these children are also differentially susceptible to persuasive design, creating a vicious cycle of excessive or compulsive exposure and engagement, and reinforcement of those decisions. Here again, our approach can offer more naturalistic, detailed, and nuanced evidence of likely causal chains of effect. We intend to grow an evidence base to support families to

make beneficial digital choices and ensure that their digital activities increasingly unfold according to their interests, upholding users' agency and autonomy.

Methods

Study Design and Setting

This study employed a five-arm between-subject acute experimental design with random self-assignment to condition. To achieve this, four iPads were placed within a public-access children's museum as a temporary 6-week play experience. This was one of many experiences available in the museum space and was positioned between two popular and permanent experiences (a large train instalment and the marketplace). Each iPad was secured to a single table that had two stools. The tables were organised as a single nest, such that users could not see the screen of the other iPads while playing. Entrance to the museum provided access to all play experiences (e.g., market, crafts, outdoor play area, theatre production, construction, block building), and children were able to elect (or not) to engage with this (and the other) play experiences for as much or as little time as they wished (and their accompanying adult allowed).

Each iPad was restricted to playing the same children's app. This app–*Giggle Scribbles,* described in the next section–is a story maker app purpose-built for this and further research. The only difference between the iPads was which persuasive design features were presented in the process of children's story creation. The experimental condition assigned to each iPad was changed at two junctures, overnight, to better balance the sample size across conditions to the extent possible, and introduce a fifth condition. An (1) active control condition consisted of base gameplay with no persuasive design. Experimental conditions added one or more persuasive design features to this base gameplay, as follows: (2) character pressure only; (3) pay-to-access locked options only; (4) a condition combining 2 and 3; and (5) all persuasive design features (i.e., character pressure, pay-to-play locked options, pop-up advertisements). Children randomly self-assigned themselves to a condition based on which iPad they chose to play, with no differences between the apps or iPads prior to commencing play that otherwise could have biased group assignment.

Story Maker App

Research into the effects of persuasive design is constrained by a lack of customisation possible with proprietary commercial apps. It is not possible to modify which, when, and how often persuasive design features of different kinds appear. Moreover, data on users' responses are not available for external scrutiny. Accordingly, to facilitate research into the effects of persuasive design on in-app behaviours– safely and responsibly–we developed a playful story maker app within which persuasive design features could be turned on and off, individually and in combination. This ensured that the only difference in the gameplay across conditions was the presence or absence of selected persuasive design features.

A story maker wireframe for this app was selected based on the team's child-first design principle and evidence of beneficial contexts for children's screen use (Mallawaarachchi et al., 2024). Specifically, the *Giggle Scribbles* story maker app was designed to: (1) be playful; (2) encourage creativity and production; (3) enable co-use, collaboration, and conversations with adults and peers; and (4) enable children to share their creations (if they wish) with family and friends. A story maker app is also directionally consistent with colouring and creation apps that often feature in the App Store's most downloaded apps for children to maximise chances that the app would be enjoyable for children. It was also designed to approximate commercially available children's creative apps, providing a

developmentally relevant and ecologically valid context in which to examine children's responses to specific design features.

Within the app, a child creates their story in the following sequence: (1) choosing one of eight characters as protagonist for their story (e.g., child, dragon, wizard, unicorn); (2) choosing one of eight backgrounds for their story (e.g., candy land, castle, beach); then, after the two are merged to create a scene, (3) colouring it in; (4) placing any number of available 'stickers' onto the scene (e.g., beach ball, hat, sunglasses); (5) recording an auditory narration for their story; and finally, (6) if desired, selecting a voice filter that alters their recorded narration (to sound, e.g., like a chipmunk, robot, dragon). This sequence is depicted in the Control condition (no persuasive design) row in Figure 1. On completion, children were able to use the iPad's Share functionality to send their story to a personal (e.g., parent's) device to take home. Upon completing a story, children could return to the home page to begin another story if they wished. Stories were not retained locally on the device, to support privacy and anonymity.

The app includes a facility to toggle on one or more persuasive design features that, when selected, embed these features at relevant junctures in the gameplay. The included persuasive design features were selected based on findings of the most prevalent and 'influential' design features within apps for children (Mallawaarachchi et al., 2023; O'Donnell et al., 2026; Radesky et al., 2022; Sousa & Oliveira, 2023). These persuasive design features were operationalised within *Giggle Scribbles* to mirror common forms, timing, and location of these features in apps designed for child use, while maximising child safety in line with our purposes for this research. The forms, locations, and timings of the selected persuasive design features are illustrated in Figure 1, separately by condition, and are also described below.

Character (Parasocial) Pressure

This persuasive design feature entails a character in the game leveraging their potential parasocial relationship with the user to encourage certain decisions or behaviour. Within *Giggle Scribbles*, the main character was a friendly, smiling Quokka (a native Australian animal) that was present on all game screens, either on the left side of the screen or, when this condition was turned on, recommending particular selections. This was operationalised by the character standing near, and pointing to, a particular character and background option. The character's desired option was pseudo-randomised to point to an option in the bottom row of options when choosing a character, and to an option in the top row of options when choosing a background. Which characters and backgrounds appeared in each position within the 2 x 4 grid of options was randomised. This served to minimise any potential location effects (e.g., tendency to pick the first or last option in an array) and desirability effects (e.g., that the persuaded option was coincidentally the most popular character or background amongst children). That is, randomisation ensured that the child's naturally preferred option would only be persuaded at chance levels (12.5% of the time).

Pay-to-Play Locked Options

This persuasive design feature renders visible in-app options or functionality unavailable to users until some form of payment (e.g., money, viewing an advertisement, completing more of the game). In *Giggle Scribbles*, this was operationalised as the bottom row of character and background options overlaid with a padlock (accordingly, if character pressure was also active, the persuaded character would be locked and persuaded background would be unlocked; see Figure 1). The three rightmost voice filters were also padlocked. If a child selected a locked item, a parental verification screen appeared, requiring them to identify a grey square in an array of four shapes (parallelling a parental verification screen that was encountered in a review of persuasive design in top charting apps for children; O'Donnell et al., 2026). Children could tap 'X' to leave this screen or attempt the parental verification prompt. If they successfully bypassed the parental verification, a dialogue box appeared to confirm their intention to purchase (e.g.,

'Unlock the dinosaur?') and a price (e.g., 'Dinosaur costs $0.99 and will be unlocked for use after purchase'). The available options were 'Cancel' or 'Purchase'. If the child proceeded with the purchase, that option became available, but no payment or payment information were collected.

Pop-up Advertisements

This feature entails advertising that suddenly appears in an overlay window, disrupting the user's play. Pop-up ads can advertise products within the app (e.g., subscription, additional functionality, intermediate currency, limited time options) and/or products external to the app (e.g., other apps or products for purchase). In *Giggle Scribbles*, this was operationalised in two ways: (1) a pop-up offer for a limited time character, costing $0.99, shown before a child was given access to the character selection screen; and (2) a 34-second advertisement for a fictional app, presented before the child received access to their completed story (the ad stayed on-screen indefinitely until selecting either X or download). In both cases, the same parental verification process was used if the child selected to purchase either or both options.

Participants

Participants were 554 young children (*M* = 4.34, *SD* = 1.20, range 1.58 – 9.83 years; 54.5% female) who self-selected to engage with the temporary iPad experience at the children's museum situated in a metropolitan region of Australia. Over its 10 years of operation, the museum has welcomed >1 million visitors from its demographically and socioeconomically diverse surrounding community (although the families that attend the museum skew somewhat higher in socioeconomic status than the surrounding region; Kervin & Howard, 2026). Consent was sought from parents/ caregivers for all children who elected to play the app, as a condition of capturing and including their data for this study. There were no other exclusion criteria.

Data Capture

There were no overt observations or interference during the child's app play, so that their play approximated their usual (e.g., at-home) digital play and preferences. Covertly, a museum staff member seconded to the iPad experience noted whether children played alone and if their play was ended at the child's volition, their parent's/caregiver's, or other reason (e.g., museum closure). During app play, user actions (i.e., selections) and timestamps were logged passively and anonymously (i.e., associated with an automatically generated alphanumeric ID for each child). This yielded two types of indices: user action data; and timing of user actions, which could be compiled to derive screen-specific and overall gameplay instances and time metrics.

User Actions

The app passively logs users' character, background, and voice filter selections, identifying also whether these were pressured and/or locked options. From these master event logs, variables were created to indicate whether the child selected a character-pressured (0 = no, 1 = yes) and/or locked option (0 = no, 1 = yes). Child attempts to purchase a locked or pop-up option were also logged. To maximise comparability between conditions, only the first story created by each child was considered for current analyses. However, also compiled from master event logs was the total number of stories each child completed.

Timing of User Actions & Gameplay

Timestamps were also captured for user actions. This was used to calculate time children spent making decisions (e.g., selecting a character) and time they spent playing the app. These were computed as the time of behaviour (e.g.,

story completion) minus onset time (e.g., starting the game).

Procedure

This study was approved by the university's Human Research Ethics Committee (HREC# 2025/109). For children who elected to play the app, and during the child's play, a staff member drew the parent's attention to our research aim, provided them an information sheet, and invited their consent to include their child's basic demographics (age, sex) and in-app responses in this study. If consent was declined the child was free to continue their play, but the in-app data logs (choices, timings) were deleted, and no further information was sought from or about the child. The staff member neither encouraged nor discouraged children from engaging with the iPads, to ensure child interest and agency. The iPads were introduced in the children's museum with no advance announcement and, after 6 weeks, were removed.

Plan for Analysis

Analyses sought to evaluate the effects of our persuasive design conditions on children's in-app selections and play time. Specifically, we evaluated whether children engaged with each persuasive design element: significantly greater than chance (chi-square goodness-of-fit); and significantly greater than total avoidance (95% CI of mean proportions). Randomisation within the app–of option locations, which option was pressured, which options were locked–meant that these contrasts could be made against chance selection. For instance, in some story creations the main character would, by chance, point to the background option a child naturally preferred (regardless of pressure). Due to in-app randomisation, however, for 7/8 games the pressured option should be something other than the child's initial preference. On this basis, if children select the persuaded option significantly more frequently than 12.5% of the time (1/8), it could be concluded that children chose the persuaded option more often than was expected without persuasion. Similarly, if children selected a locked option significantly more than 0, it could be concluded that children did not consistently avoid those options (as might be desirable when, e.g., young children encounter pay-to-play locked options). Contrasts were explored for each persuasive design feature separately and, where possible, combined. Finally, chi-square analyses evaluated effects of persuasive design condition on completion of a story. ANOVAs evaluated the effects of persuasive design condition on the number of stories completed and duration of gameplay. Due to the non-normal distribution of gameplay duration and the number of stories created, a log transformation and a square root transformation, respectively, were performed. Descriptive statistics are reported in their original scale to support interpretability.

Declarations

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References

1. Babaei, P., & Vassileva, J. (2025). Enhancing User Awareness of Manipulative Designs: A Study on Persuasive Strategies for Mobile App Platforms. *ACM J. Responsib. Comput.*, *2*(4), Article 19. https://doi.org/10.1145/3766544
2. Breitwieser, J., & Reinelt, T. (2026). The effectiveness of implementation intentions in children: A systematic review and meta-analysis. *British Journal of Psychology*, *n/a*(n/a).

https://doi.org/https://doi.org/10.1111/bjop.70065

3. Brignull, H., Leiser, M., Santos, C., & Doshi, K. (2010). *Deceptive patterns – user interfaces designed to trick you.* . https://old.deceptive.design/
4. Calvert, S. L. (2017). Parasocial relationships with media characters: Imaginary companions for young children's social and cognitive development. In *Cognitive development in digital contexts* (pp. 93-117). Elsevier.
5. Chang, W. J., Seaborn, K., & Adams, A. A. (2024). *Theorizing Deception: A Scoping Review of Theory in Research on Dark Patterns and Deceptive Design* Extended Abstracts of the CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA. https://doi.org/10.1145/3613905.3650997
6. Darin, T., & Carneiro, N. (2025). From understanding to intervention: Towards an agenda for countering dark patterns in games. International Workshop on Interaction and Player Research in Game Development,
7. Fogg, B. (2009). *A behavior model for persuasive design* Proceedings of the 4th International Conference on Persuasive Technology, Claremont, California, USA. https://doi.org/10.1145/1541948.1541999
8. Gollwitzer, P. M., & Crosby, C. (2018). Planning out future action, affect, and cognition.
9. Gray, C. M., Santos, C. T., Bielova, N., & Mildner, T. (2024). *An Ontology of Dark Patterns Knowledge: Foundations, Definitions, and a Pathway for Shared Knowledge-Building* Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA. https://doi.org/10.1145/3613904.3642436
10. Hardwick, T., Carter, M., Harkin, S., Zhangshao, T., & Egliston, B. (2025). *"They're Scamming Me": How Children Experience and Conceptualize Harm in Game Monetization* Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems, https://doi.org/10.1145/3706598.3713611
11. Helamo, A. (2023). Fighting the dark side: a scoping review of dark pattern mitigation.
12. Kervin, L. K., & Howard, S. J. (2026). Understanding the Impact of Children's Museums: A Decade of Evidence from Children and Families. In A. Rorbaek & N. Holdgaard (Eds.), *Museum Play: Concepts, Design and Audiences*.
13. Khan, N., Daud, H. E., & Shahid, S. (2025). Mind the Dark: A Gamified Exploration of Deceptive Design Awareness for Children in the Digital Age. *arXiv preprint arXiv:2506.23017*.
14. Kleinman, Z. (2019). 'My son spent £3,160 in one game'. *BBC*. https://www.bbc.com/news/technology-48925623
15. Krahl, H., Hartwig, K., Fischer, A.-K., Nikolakopoulou, T., Cabritas, G. P., Ungeheuer, E., Gerber, N., & Stöver, A. (2025). Playful but Persuasive: Deceptive Designs and Advertising Strategies in Popular Mobile Apps for Children. *arXiv preprint arXiv:2512.17819*.
16. Livingstone, S., & Helsper, E. J. (2006). Does Advertising Literacy Mediate the Effects of Advertising on Children? A Critical Examination of Two Linked Research Literatures in Relation to Obesity and Food Choice. *Journal of communication*, *56*(3), 560-584. https://doi.org/10.1111/j.1460-2466.2006.00301.x
17. Livingstone, S., Ólafsson, K., & Pothong, K. (2025). Digital play on children's terms: A child rights approach to designing digital experiences. *New Media & Society*, *27*(3), 1465-1485.
18. Lu, Y., Zhang, C., Yang, Y., Yao, Y., & Li, T. J.-J. (2024). From Awareness to Action: Exploring End-User Empowerment Interventions for Dark Patterns in UX. *Proc. ACM Hum.-Comput. Interact.*, *8*(CSCW1), Article 59. https://doi.org/10.1145/3637336
19. Luguri, J., & Strahilevitz, L. J. (2021). Shining a Light on Dark Patterns. *Journal of Legal Analysis*, *13*(1), 43-109. https://doi.org/10.1093/jla/laaa006
20. MacKenzie, J. E., Klarkowski, M., Horton, E. M., Theobald, M., Danby, S., Kervin, L., Barrie, L., Amery, P. K., Andradi, M., Smith, S. S., Mandryk, R. L., & Johnson, D. (2024). Using Psychophysiological Data to Facilitate Reflective Conversations with Children about their Player Experiences. *Proc. ACM Hum.-Comput. Interact.*, *8*(CHI PLAY), Article 347. https://doi.org/10.1145/3677112

21. Mallawaarachchi, S., Burley, J., Mavilidi, M., Howard, S. J., Straker, L., Kervin, L., Staton, S., Hayes, N., Machell, A., Torjinski, M., Brady, B., Thomas, G., Horwood, S., White, S. L. J., Zabatiero, J., Rivera, C., & Cliff, D. (2024). Early Childhood Screen Use Contexts and Cognitive and Psychosocial Outcomes: A Systematic Review and Meta-analysis. *JAMA Pediatrics*. https://doi.org/10.1001/jamapediatrics.2024.2620
22. Mallawaarachchi, S., Cliff, D. P., Neilsen-Hewett, C., White, S. L. J., Radesky, J., Horwood, S., Johnson, D., Kervin, L., & Howard, S. J. (2025). Effects of Persuasive App Design and Self-Regulation on Young Children's Digital Disengagement. *Human Behavior and Emerging Technologies*, *2025*(1), 8187768. https://doi.org/https://doi.org/10.1155/hbe2/8187768
23. Mallawaarachchi, S. R., Tieppo, A., Hooley, M., & Horwood, S. (2023). Persuasive design-related motivators, ability factors and prompts in early childhood apps: A content analysis. *Computers in Human Behavior*, *139*, 107492. https://doi.org/https://doi.org/10.1016/j.chb.2022.107492
24. Meyer, M., Adkins, V., Yuan, N., Weeks, H. M., Chang, Y.-J., & Radesky, J. (2019). Advertising in Young Children's Apps: A Content Analysis. *Journal of Developmental & Behavioral Pediatrics*, *40*(1). https://journals.lww.com/jrnldbp/fulltext/2019/01000/advertising_in_young_children_s_apps__a_content.4.aspx
25. O'Donnell, N., Klarkowski, M., MacKenzie, J., Horton, E., Mallawaarachchi, S., Howard, S. J., & Johnson, D. (2026). From playful to manipulative: Exposing deceptive patterns in digital applications for young children. *International Journal of Child-Computer Interaction*, *47*, 100804. https://doi.org/https://doi.org/10.1016/j.ijcci.2026.100804
26. Ofcom. (2025). Children and parents: media use and attitudes. https://www.ofcom.org.uk/media-use-and-attitudes/media-habits-children/children-and-parents-media-use-and-attitudes-report-2025
27. Office of the e-Safety Commissioner. (2019). *Safety by Design*. https://www.esafety.gov.au/sites/default/files/2019-10/SBD%20-%20Overview%20May19.pdf
28. Radesky, J., Hiniker, A., McLaren, C., Akgun, E., Schaller, A., Weeks, H. M., Campbell, S., & Gearhardt, A. N. (2022). Prevalence and Characteristics of Manipulative Design in Mobile Applications Used by Children. *JAMA Network Open*, *5*(6), e2217641-e2217641. https://doi.org/10.1001/jamanetworkopen.2022.17641
29. Schäfer, R., Sahabi, S., Karl, L., Hahn, S., & Borchers, J. (2025). *"If They Have No Choice, They'll Accept!": How Children and Adolescents Assess Deceptive Designs* Proceedings of the 24th Interaction Design and Children, https://doi.org/10.1145/3713043.3731497
30. Schaffner, B., Heysen, L., & Chetty, M. (2026). *A Systematic Review of User Experiments on the Effects of Dark Patterns* Proceedings of the 2026 CHI Conference on Human Factors in Computing Systems, https://doi.org/10.1145/3772318.3790383
31. Shah, J. Y., Friedman, R., & Kruglanski, A. W. (2002). *Forgetting all else: On the antecedents and consequences of goal shielding* [doi:10.1037/0022-3514.83.6.1261].
32. Sousa, C., & Oliveira, A. (2023). The dark side of fun: Understanding dark patterns and literacy needs in early childhood mobile gaming. European Conference on Games Based Learning,
33. Sundar, S. S., & Chen, J. (2023). From CASA to TIME: Machine as a source of media effects. In A. L. Guzman, R. McEwen, & S. Jones (Eds.), *The SAGE handbook of human-machine communication* (pp. 63-72). SAGE Publications Ltd,. https://doi.org/https://doi.org/10.4135/9781529782783.n9
34. Video Games Europe. (2024). In-game spending by children & parent supervision. https://www.videogameseurope.eu/publication/in-game-purchases-in-european-markets-2024-data/
35. Villanueva, F. L., Gaskell, G., Veltri, G. A., Theben, A., Folkford, F., Bonatti, L., Bogliacino, F., Fernández, L., Marek, E., & Codagnone, C. (2016). Study on the impact of marketing through social media, online games and mobile applications on children's behaviour.

36. Zhang, G. X., Wang, Y., Nakajima, T. L., & Seaborn, K. (2025). First Contact with Dark Patterns and Deceptive Designs in Chinese and Japanese Free-to-Play Mobile Games. *Proc. ACM Hum.-Comput. Interact.*, *9*(6), Article GAMES025. https://doi.org/10.1145/3748620

Tables

Table 1 App Play Metrics, by Condition

	No PD		**Character Pressure**		**Locked Options**		**CP + Locked**		**All On**	
	n	**M (SD)**	**n**	**M (SD)**	**n**	**M (SD)**	**n**	**M (SD)**	**n**	**M (SD)**
App play metrics										
Play time	**134**	**6.86 (6.36)**	**129**	**6.13 (4.53)**	**102**	**7.40 (4.29)**	**63**	**6.44 (4.26)**	**126**	**7.25 (4.78)**
Completed story	43	8.76 (7.40)	49	8.03 (4.12)	35	9.49 (5.26)	25	7.05 (3.21)	27	7.97 (4.73)
Did not complete story	91	5.95 (5.62)	80	4.97 (4.40)	67	6.32 (3.23)	38	6.03 (4.82)	99	7.05 (4.80)
Total number of stories		**2.16 (2.00)**		**2.52 (2.68)**		**2.01 (2.44)**		**1.85 (1.41)**		**1.91 (1.85)**

Note. Where children only partially completed a story, this was coded as 1 story for purposes of calculating the number of stories for each child. All children reached the colouring screen and only 5 did not finish their colouring. Thereafter, a descending proportion of children completed stickering (ranging from 56.3% in the All On condition to 76.9% in the No PD condition), recording (ranging from 40.5% in the All On condition to 54.5% in the No PD condition), and finally the voice filter screen (ranging from 24.6% in the All On condition to 38.1% in the locked option + character pressure condition).

Figures

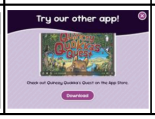
	Screen 1		Screen 2	Screen 3	Screen 4	Screen 5	Screen 6	Screen 7	
Condition	Limited Time Offer	Character Selection	Background Selection	Colouring	Sticker Selection	Voice Recording	Voice Filters	Pop-up Ad	End Screen
No PD (Base Gameplay)	N/A							N/A	
CP only	N/A			No Diff.	No Diff.	No Diff.	No Diff.	N/A	No Diff.
P2P LO only	N/A			No Diff.	No Diff.	No Diff.		N/A	No Diff.
CP+P2P	N/A			No Diff.	No Diff.	No Diff.		N/A	No Diff.
All On				No Diff.	No Diff.	No Diff.			No Diff.

Figure 1

Giggle Scribbles Gameplay Sequence, by Condition

Note. No PD = base gameplay without the studied persuasive design elements. Gameplay proceeded from Character Selection (Screen 1, far left) to End Screen (Screen 7, far right). Each row below this represents a different persuasive design condition and depicts what was consistent with the base gameplay (“No Diff”) or what differed from the base gameplay (fully opaque aspects of image identify changed element/s).

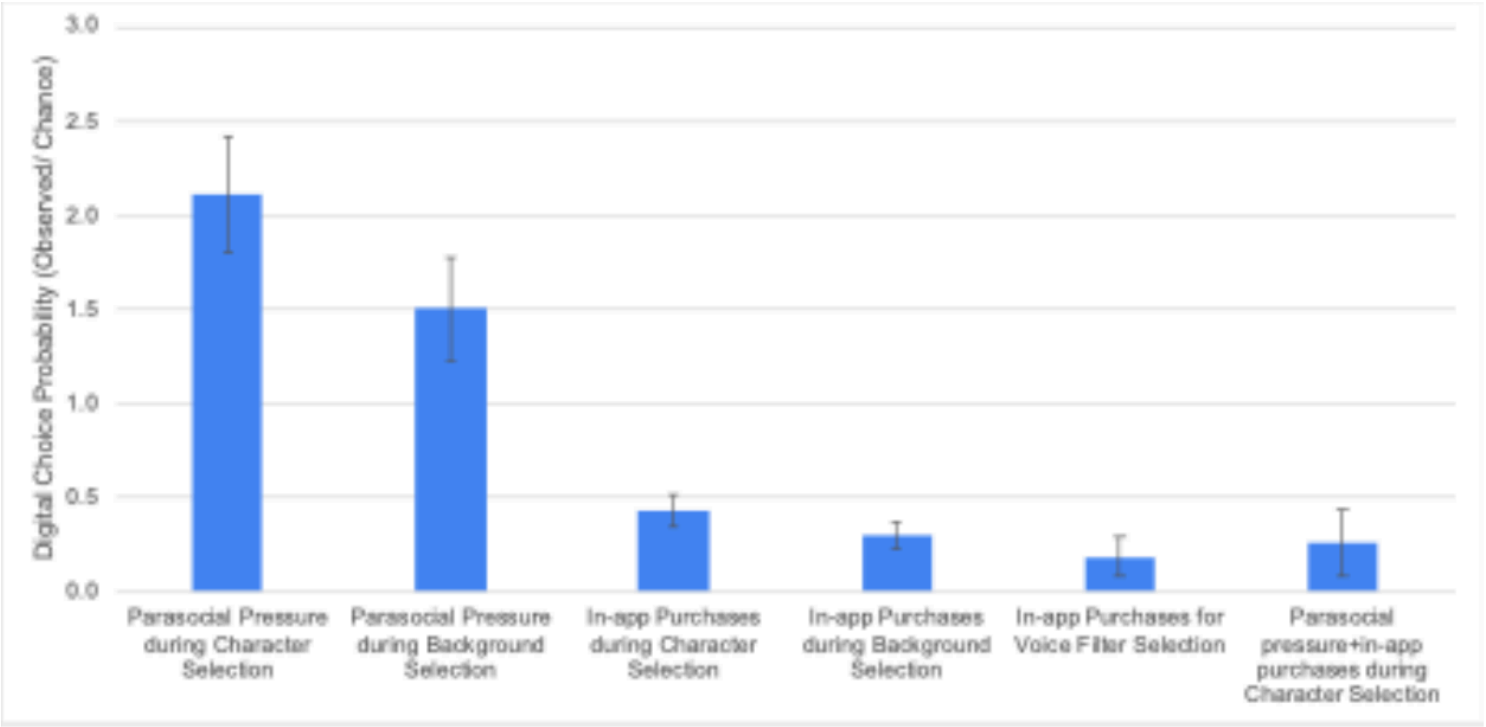


Figure 2

Probability of Selecting a Persuaded Option, by Type and Screen

Note. Values above 1 indicate greater than chance probability of selecting the persuaded option (e.g., a value of 2 would indicate 2x greater likelihood of selecting a persuaded option than chance). Values below 1 indicate lower than chance probability of selecting a persuaded option.