Crescendo: Routine Learning App for Children with Autism Spectrum Disorders

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Abstract
Crescendo is an ongoing project aimed to provide children with High Functioning Autism, their teachers and carers with a communication tool that bridges them. *Crescendo* guides carers in teaching and immersing their child in a virtual environment that mimics the real world, helping them to make sense of it and interact with objects and places in order to become self-reliant in atomized, step-by-step routines. *Crescendo* is a two-sided app design, one for carers and another for children. It provides both with tool for monitoring and incremental step-by-step learning.

Author Keywords
Autism app design, Autism spectrum, Learning, Communication, Interaction design

ACM Classification Keywords
Design.

Introduction
Autism is the confluence of heterogeneous neurodevelopmental conditions, with high incidence of comorbidities (Lai et al, 2016). This condition is characterized by a triad of impairments: 1) social interaction, 2) social communication and 3) imagination

impairments, in addition to notable repetitive behavior patterns (Bogdashina, 2006). Children with High Functioning Autism are situated within the less severe end of the Autism Spectrum Disorder (ASD). These children are within the average IQ levels, and some have psychomotor, learning, speech and social impairments that makes them challenging to educate and foment independence.

With *Crescendo*, we aim to provide our users (High Functioning Autism children) with an adequate tool that can promote child autonomy while assuring carers that their child is engaged in the learning process, whilst carers can keep a close watch and track of their child's achievements. *Crescendo's* goals are two folded, on one side it has the ability to help carers understand which development stage their child is, and guides them in the process of teaching their child everyday tasks that ensure quality life for both carers and child. On the other it guides and reassures the child in each step of the activity proposing tips and alternatives in case of impediments found along the way.

Crescendo

Our design process started by looking at some of the available solutions in the domain of High Functioning Autism support. vSked (Cramer et al, 2011) is one of the most prominent solutions that inspired our design, it is described by its authors as "*interactive and collaborative assistive technology for students with autism, combining visual schedules, choice boards, and a token-based reward system into an integrated classroom system*". This solution has proven successful for teaching students goal oriented tasks. What we found that this app lacked is the ability to be used outside the classroom environment. *Crescendo*, on the other side, is designed to be used anywhere from getting to know the walk between its house and school to how to feed their cat.

Another solution that has greatly influenced our design is the time-long proven PECS (Picture Exchange Communication System). The most important aspect of PECS that influences our design is the fact that all tasks are atomized to all steps needed to finish it with success. Compared to PECS, *Crescendo* adds a peer component to its design. The findings on positive influence of virtual assistants on children with ASD are positive, as they help people with autism understand emotions and social cues for better interpersonal relationships (Merryman et al, 2008). In our design, we use a mascot that can be personalized to the child needs. The reason why we chose to include a virtual assistant is to make the app immersive and engaging, especially when the child is required to complete tasks that need to follow a specific sequence. In these scenarios the virtual assistant can highlight the steps to take, and reinforce the child when they have accomplished their task. The mascot also plays an important role when the child is outside their home or school, by "jumping" to the street and inviting the child to follow it through augmented reality.

Concept Validation Process

We talked to some carers at an Autism Parents Association, where we listened to their worries and needs and brainstormed a design solution through participatory design approaches. Then we talked about our concepts and some caregivers showed clear interest in having this in the early stages of a service user's routine education process. Nevertheless, some carers mentioned that our solution could cause disruption to

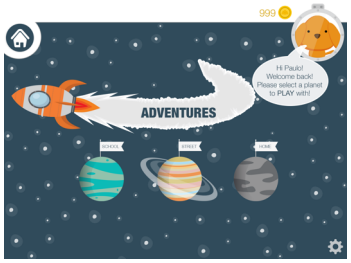

Figure 1: Child's app main menu

Figure 2: Child's home menu

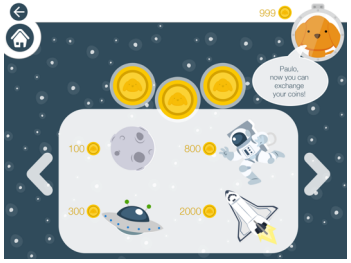

Figure 3: Child's app coins menu

users with a strict and effective routine strategy. We were also told that many children are proficient in the use of ICT (Information, Communication Technologies).

Process

Crescendo has a virtual schedule and two distinct app clients: the child's gateway and the carer's gateway. Both have their own interfaces and tools but remain complementary to each other. Carers are required to answer a series of surveys, according to the area in which they want to teach their child. These surveys are Self-Help Skills Inventory, Self-Care Assessment and Home-Care Assessment (Baker et al, 2004). Depending on the child's performance, the app can suggest starting tasks. Carers are recommended to keep consistent with their routines and to start small. That is, to start with a task that is about 3-4 steps, like feeding a cat. These tasks have low repercussion and are safe, they allow the child to interact with the app frequently, making the child acquainted to the process of finishing it and being rewarded. Carers are required to do this routine many times, until the child gets a fair understanding of the steps. This is important, as vicariant reinforcement is beneficial.

In the app, the child has access to a virtual environment that mimics the scenario the child has to complete a task (e.g. Kitchen), this brings navigational aid, by highlighting the atomized step-by-step tasks that the child has to do. By having the child repeat the process first in the virtual setting and then on the real world, reinforces the sense of sequence.

Crescendo Children Design App

The template (Figure 1) of our game's concept design can be customized by users, in the following pictures we've chosen to design for one single template.

The top bar is always visible in every app's screen. It has the essential information: mascot, coins and home button. Users are always accompanied by a mascot that is the loyal companion that will be guiding and helping them through the game. After a game is completed users win a specific number of coins that they can exchange for several items to customize its current template (Figure 3).

In this case in the main menu we have 3 sections where they choose what to play with. Each section is a different adventure at a different scene. These scenes are customized by the carer, in this case we have adventures at the school, at the street and at home. We only prototyped for home and street. Each section will open a menu and the screen will show several places where users can play. Users only need to swipe between these places to choose where they want to play.

At *home dimension* (Figure 2), we can swipe between living room, kitchen and bedroom. Each one will have different games to play, all of which have the same structure of game. In this case we've prototyped for a game in the kitchen (Figure 7) that is to complete the task of feeding the cat, here we show the step-by-step learning and gaming components.

In the bottom bar users are able to see each step that they need to do to complete their task successfully. In the first step users need to click on the switch to light

Figure 4: Child's street menu

Figure 5: Child's map aerial view

Figure 6: Child's map street view

the room. Then they need to click on the milk, then on the cat's bowl and then they see that the bowl is full of milk, so the next step is to click on the milk again and on the shelf to put back the milk in the place where it belongs.

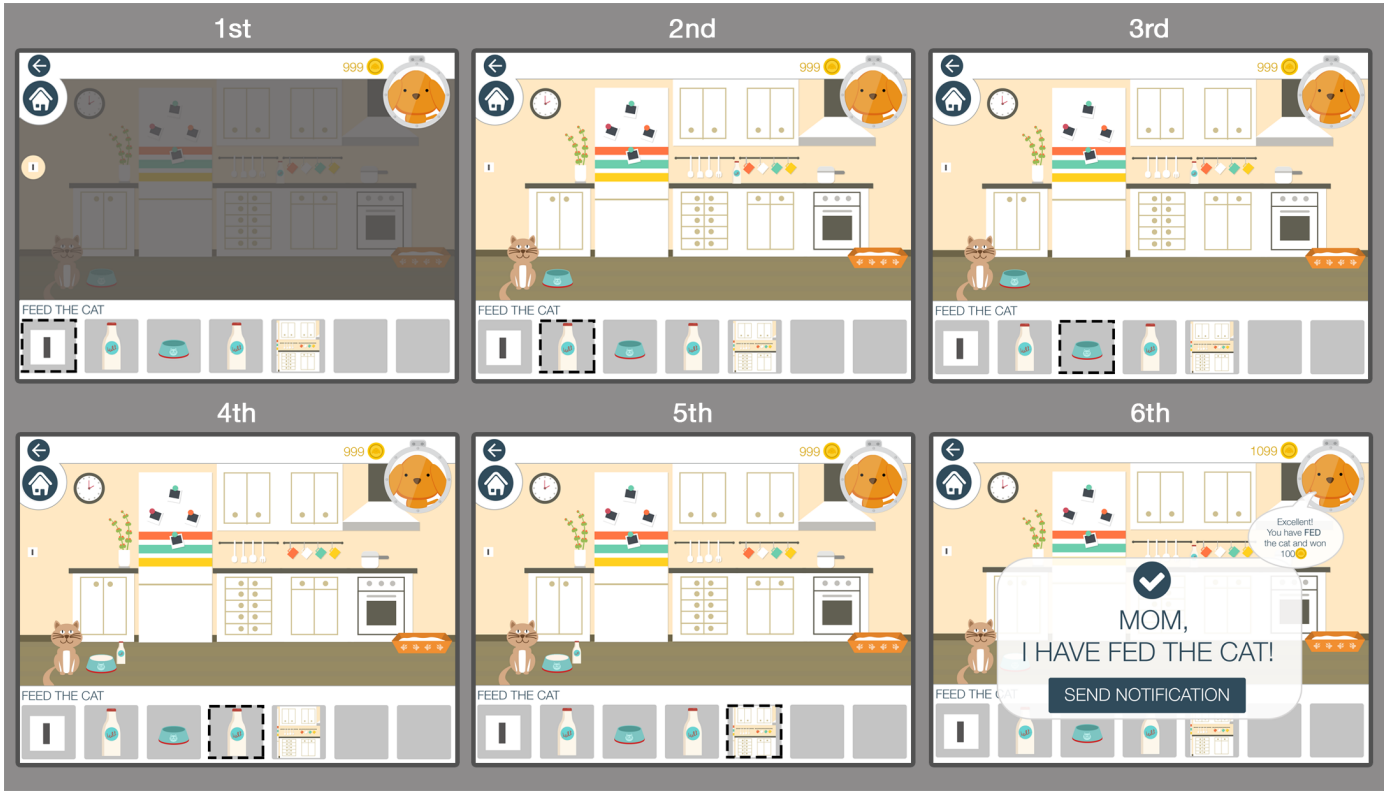

Figure 7: Child's app, 6 print screens of the feeding cat task

Through this game, users have immediate feedback when moving objects through the scenario. When users end one task their mascot notifies them how many coins they've won, and they are able to send a notification to their guardian saying they've finished their task, in this case they've fed the cat.

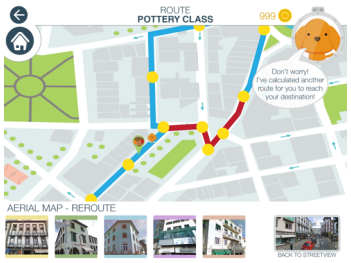

Figure 8: Child's reroute

Figure 9: Child's notification

Figure 10: Guardian's tasks menu

In the main menu if they choose *street section* (Figure 4) they can swipe between garden, pottery class and granny's house and others that the carer has previously customized. We prototyped for pottery class to show the guidance and tracking components of the app. Once the users click on pottery class they see the map with each milestone that they need to reach, in order to get to pottery class. Our mascot will be guiding them (Figure 5). In the bottom bar they are able to see each step that they need to perform until they reach the final destination. Those steps are marked by buildings, and if they click on the button *for street view* (Figure 6), they are able to see those buildings highlighted and the mascot in the street guiding them. If there is any problem with their normal route, the mascot will calculate another route for them so they can reach their final destination (Figure 8). In this case the guardian will be automatically notified about that change. When they finally reach the destination the users notify their guardians (Figure 9).

Crescendo Guardian Design App

The left bar (Figure 11) of *Crescendo Guardian's* app is always visible in every app's screen. It has the essential information: home, tracking, notifications and a settings button. Each section has essential information for carers to know how and what their child is doing. In the *home section*, carers can click on *My Tasks* button (Figure 10) and they are lead to an information's screen about the tasks that their child has completed and task success, spatial awareness and fine motricity's progress bars. Carers are able to swipe between their children's pictures, if they have more than one using the app.

At *My Routines* button in the home screen, carers are able to type which activities children have and this information will appear in the home screen, remembering carers what children will do on that day. At *My Places* button (Figure 12) carers are able to see the child's screen and add several places to go and customized it with tasks. In the *tracking section* (Figure 13) carers are able to track where their child, and they get notified about which route he is taking.

Figure 11: Guardian's main menu

Conclusion & Future Work

In summation, our design concept is a two-sided app. tailored to meet the needs and tasks of its target users, creating an education game and intuitive tool that aids autistic people in learning step-by-step tasks always supported by their caretakers. This concept was rooted in five prompts: step-by-step learning, tracking, gaming, guidance and carer's peace of mind. With *Crescendo* carers know that their children can do a task without hurting themselves and they are always notified about what the children are doing. If something

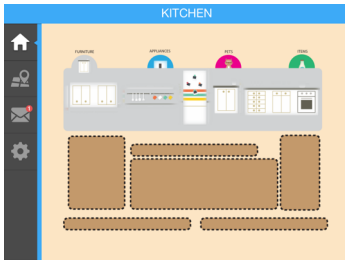

Figure 12: Guardian's places

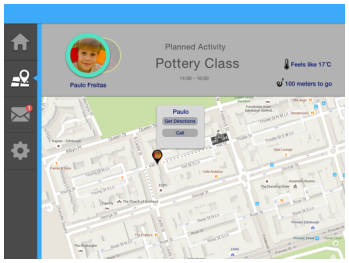

Figure 13: Guardian's tracking

unplanned happens during the task performance task, carers are notified or the mascot helps the children.

Our design, at this stage, lacks empirical data from real users, but we are working closely with institutions in order to deploy prototypes, and to gather information that support design changes for the learning process of these children. We also envision to add another core feature to our design, this feature is especially useful to understand the triggers of specific challenging behaviors, it consists in logging the place, time, temperature, noise level and participants in order to understand which settings are likely to trigger a challenging behavior, ultimately mapping them in order to predict when all the conditions are favorable to incite stress in the child, resulting in challenging behaviors.

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