Table of challenges and potential solutions (e.g. methodological, technical, population-specific):

Table 1. Methodological challenges

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| **Challenge encountered** | **Potential solution/recommendations** |
| Child did not engage with robot when presented alone | Have an introduction session prior to the start of the robot phases, where the caregiver introduces the robot as the helper for washing hands, and give some opportunity for the robot to interact with the children as a group briefly in an engaging activity, such as singing / dancing.  Also, conduct a training phase where the caregiver teaches each child to follow the robot prompts during hand-washing. |
| Training phase needs to be formalized so that the caregiver can follow a reproducible protocol in prompt fading and reinforcement schedule | The training phase’s overall aim is to fade caregiver’s involvement systematically until the child is able to wash hands needing only robot prompts. The caregiver involvement can be broken into these levels, in decreasing order: caregiver behind child and guide child in following robot prompts, caregiver behind child and correct child behaviors through nudging (or guiding if nudging ineffective) in following robot prompts, caregiver stand beside child and correct child behavior physically in following robot prompts (nudging or guiding), caregiver stand beside child and correct child behavior through pointing (and physically if pointing ineffective) in following robot prompts. Positive reinforcement should be given immediately after the completion of every get soap step, rinse step, and dry step. |
| Need to control the confounding effects of the child learning as the study progresses in our comparison of prompt compliance and task execution. In addition, need to test for maintenance of skill acquisition in absence of ATC | We propose a five phase study that has two variations: A-B-C-D-A and A-C-D-B-A. Phase A is the baseline phase, where the caregiver tests the child’s hand-washing skill, lets the child to wash hands by themselves and only help if the child shows no progress in twenty seconds. The caregiver offers no prompts, and only helps by completing the stuck step for the child. Phase B is the parent prompt phase, where the parent proactively prompt each step. Phase C is the robot parent training phase, where the robot proactively prompt while the parent instructs the child to follow the robot prompts. Phase D is the robot prompt phase, where the robot proactively prompt each step. The reason we repeat phase A again in the end is to test for skill acquisition in absence of ATC, and quantify the learning effect of the study as a whole. The reason we have two variations of the phases, and each child randomly assigned to one of the variations, is to counter balance the learning’s confounding effect on our comparison of prompt compliance and task execution between robot and parent. The reason we do not have two robot prompt phases flanking the training phase (unlike the WoZ conducted in this thesis) is because the necessity of the training phase has already been shown by this thesis. However, a study devoted to comparing different forms of the training phase on robot prompt compliance and task executions may also be beneficial. |
| Need to collect data to saturation for all phases and the sample size for each phase needs to be statistically significant, and the need to include statistical analysis in the study | Using c-statistics for analysis, the study with minimum of eight trials per phase or as many trials as needed for the child’s behavior to be stabilized for each phase should be conducted. |
| Need to compare robot prompt vs. video prompt | We need justification for using the more costly robot rather than a cheaper multimedia system displaying video modelling to prompt the child, thus conducting a study where the video prompt vs robot prompt is compared on compliance, engagement, and task execution will be needed. |

Table 2. Population-specific challenges

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| **Challenge encountered** | **Potential solution/recommendations** |
| Do not know how to measure engagement | This thesis attempted to investigate if the child is more engaged when prompted by a humanoid robot. However, the literatures offered little clues on how to measure engagement level for children with ASD. Possible features that reveal engagement should couple with sensory inputs that is salient to the individual, and may vary across individuals. For our participant, visual attention was a poor indicator of engagement. Instead, verbal feedback was seen as a possible indicator. For future studies, survey / interview to caregiver may be used to gather clues of what is a good indicator of engagement for each individual participant. Also, visual attention, verbal feedbacks, among other forms of interactions, may be candidates for engagement level indicator. |
| Child unfamiliarity with washroom and robot, fatigue to repetitiveness and lack of natural motivation of the trials, need for clinically significant population sample size | Conduct the study in an autism school, where trials are only conducted when natural motivations arise for hand-washing. The trials should be conducted on a daily fashion, integrated into the child’s daily routine, over a period of more than a month |
| More specific inclusion criteria controlling participants’ hand-washing levels | The current inclusion criteria are appropriate except missing one criteria – participant hand-washing level. Children with ASD have varying abilities of daily of living skills. Specifically for hand-washing, the child may require prompts on how to execute each step, or on which steps to do next, or simply just on initiating the hand-washing activity and being reminded to be on task when distractions occur. Future studies should select one group of users based on this classification, and design robot behaviors specifically for this group. |

Table 1.Technical challenges

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| **Challenge encountered** | **Potential solution/recommendations** |
| Do not know how the robot can better engage the child to look at prompts and in the activity in general | The robot can be more visually engaging by exhibiting greater range of motion, faster, and more animated gestures. Also, cartoon sounds and flashing LEDs can also be used to engage the child in general, for example, as rewards. |
| Child does not wait for prompts due to robot prompt delays | Minimize pause between robot gestures / verbal prompts, and create shorter versions of the prompts for the extended steps (e.g. rinse step) so the shorter prompts are repeated in a rapid manner (e.g. every two seconds). |
| Child does not comply to prompts | Need a more severe version of each prompt (shorter verbal prompt with more commanding posture for gesture, may include the child’s name in the verbal prompt), which is used when child is not complying to prompts. Also need a “call for caregiver prompt” so that the child learns that his/her noncompliance is the reason for caregiver’s interventions. |
| Child sometimes gets too much soap | Need a “stop getting soap” prompt |
| Operator is unfamiliar with the child's behaviors and hand-washing habits, and the robot control needs to be tested out before the start of the study | Record the parent prompt phase (Phase B) and have the operator practice controlling the robot using the recorded videos so that the robot is able to prompt each step proactively just like the parent. |