Do Therapists Use Object Affordances to Develop Functional Activities for Task-Oriented Therapy: Implications for Robot-Assisted Task-Oriented Therapy

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ABSTRACT

Background: The use of objects in rehabilitation therapy has long been considered critical and occupies an important place in the framework of the profession. However, there is not enough evidence to provide a clear understanding of how objects are used in therapy and how therapists consider object affordances during interventions.

Purpose: The main purpose of this study is to quantitatively analyze the relationship between objects and tasks chosen by therapists. This relationship will be used to validate a computer algorithm predicting activities based on object affordances using the Activities of Daily Living Exercise Robot (ADLER).

Methods: 62 OT students and 12 OT practitioners completed a survey requiring them to choose activities that could be performed based on images of objects provided.

Results: Results showed that use of objects could be classified as having high, medium, or low affordances and that there were some differences between the perception of object affordance by OT students and OT practitioners with stroke therapy experience.

Conclusion: This study was successful in empirically identifying and understanding the concept of object affordance by OT students and occupational therapists and will prove useful in providing a realistic context to rehabilitation roboticists as they develop and program robots for ADL interventions.

INTRODUCTION

Rehabilitation practitioners use objects as a critical part of their interventions and treatment (Hocking, 2008). Individuals identify themselves by the objects they create, own and use in their lives (Hocking, 2000). Therapists often use objects to facilitate engagement in activities that subsequently impacts health, wellness and overall life participation.

Although objects have been used as a therapeutic intervention for decades, there is limited research on how therapists choose specific objects for their interventions. The purpose of this paper is to understand how the therapeutic choice of activities is influenced by object affordances. Object affordances refers to the characteristics or attributes of an object that it offers for potential actions (Wu, Trombly, Lin, & Degnen, 1998; Hetu & Mercier, 2012). For example, if there is no object present during a task then there is no object affordance (Hetu & Mercier, 2012). Whereas perfect object affordance means that a task is completed using the appropriate object(s) that have meaning to the patient (Hetu & Mercier, 2012). Object affordances can impact individuals' reactions to certain items and how they use them in activities (Bach, Nicholson, & Hudson, 2014). Bach et al. (2014) proposed the affordance-matching hypothesis, which describes how knowing an object's characteristics, purpose, and one's previous experience with it, can influence an individual's action. This hypothesis also assumes the information about the object can be used to predict and further understand how others act (Bach et al., 2014). This hypothesis is not as effective if applied to unknown objects or common objects that are used in uncommon ways (Bach et al., 2014).

Studies have shown that object affordances have influenced client's motor performance during rehabilitation (Hetu & Mercier, 2012; Lin, Wu, Chen, Chern, and Hong, 2007; Wu, Trombly, Lin, & Degnen, 1998; Wu, Trombly, Lin, and Degnen, 2000). Lin et al. (2007) found that although having an object in hand did not

significantly improve reaching performance, it did reduce the average velocity of the task, and therefore improved balance and postural control. Wu et al. (2000) determined that clients improved movement kinematics in the presence of objects versus no objects. Hetu and Mercier (2012) found that increasing object affordances can improve client's motor performance during therapy. Object affordances can be modified by adjusting the number or the symbolic attributes of the objects present to complete the task (Hetu & Mercier, 2012; Wu et al. 1998). When clinicians use enriched object affordances during therapy tasks, it has a positive influence on motor performance compared to a lower level of object affordances (Hetu & Mercier, 2012; Wu et al. 1998). Wu et al. (1998) found that using natural objects which have enriched object affordances facilitated a positive effect on movement kinematics in individuals with and without cerebrovascular accident. Although these studies showed how objects affect a client's performance, they did not examine how the therapist chose specific objects for the activity.

This study analyzed how object affordances can influence the choice of therapeutic activities. The long-term goal of this project is to use the information about the process that therapists use to choose objects for certain activities in the design of the Activities of Daily Living Exercise Robot (ADLER) (Chrungoo & Johnson, 2015). Activities of Daily Living Exercise Robot (ADLER) is an upper body stroke rehabilitation therapy robot that helps stroke survivors to perform daily living activities like drinking, eating etc. When presented with a list of objects in the robot's therapy environment, the robot estimates a list of tasks that could be performed with the given set of objects in the context of daily living activities based on a trained machine learning and prediction algorithm (Chrungoo, Shirsat, & Johnson, 2015). Johnson and Wisneski (2007) found that grasp patterns and movement in planes differ when different objects are present in the therapy environment. This study shows that functional task training is dependent on the objects available, and those objects will impact the way that a person moves in a therapy session.

Robots, like humans need to know the relationship of objects to tasks in order to help the clients perform those tasks in robot-assisted therapy. This relationship involves the environment in which the tasks are performed. In recent studies, there has been observation and analysis of grasping patterns and affordances, and algorithms to predict them. These algorithms are related to picking and placing of objects, and handing objects between humans and robots (Aleotti, Michelli, & Caselli, 2014; Aleotti, Rizzini, & Caselli, 2014). The exploration of this topic is important and understanding the way that robots and humans will interact in the future will help to frame robot-assisted therapy practice.

The main purpose of this study is to quantitatively analyze the relationship between objects and tasks chosen by therapists. This relationship will be used to validate a computer algorithm predicting activities based on object affordances using ADLER.

METHODS

This study used a two-group exploratory design. The two participant groups were occupational therapy students and licensed occupational therapy practitioners. A survey methodology was used to collect the data. The survey was designed to evaluate how occupational therapy students and practitioners use objects for task choices during therapeutic interventions.

The survey was distributed to occupational therapy students at an urban university and to occupational therapy practitioners via social media resources (blogs, national associations, and facebook). Only results from participants who completed the entire survey were included. The survey was created on the Qualtrics platform and included 60 questions. It was pilot tested by 6 students and 2 faculty for usability and feedback was incorporated into the final version. The survey included 3 sections: the informed consent, demographics and object affordance section. The section on object affordances included questions that displayed the objects that were selected for the study. The user was prompted to choose activities that were possible with just the objects in the images. For example, a person was presented

with a plate, a sponge, and a knife and asked to choose which of the tasks listed were possible with only the objects shown (Figure 1).

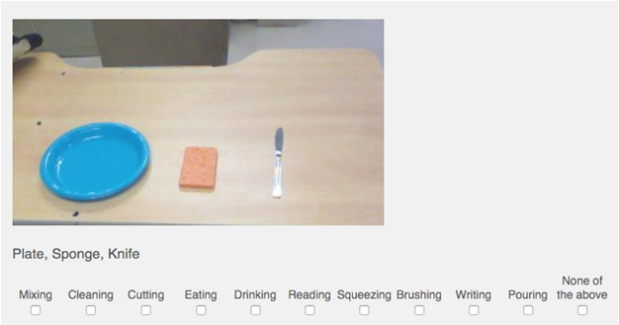

Figure 1: Example of object affordance question

Of the sixty images, there were twenty images that contained two objects, twenty images that contained three objects, and twenty images that contained four objects. The images were identical except for the changing objects to reduce bias. Additionally, each object was shown the same amount of times within those sixty objects. These combinations were created randomly.

Data was analyzed using Matlab and Microsoft Excel. The data was organized by the type of activities chosen for each of the 60 images. Only choices that were made by 50% or more of the participants were chosen for analyses. All images containing each object were compared to each other in 20 separate charts to show if any similarities existed between the images. The matrix showing the participants' activity mapping was also displayed below each of these 20 charts in order to further understand why specific activities were chosen for each image.

RESULTS

62 occupational therapy students and 12 occupational therapy practitioners completed the survey. Activity choices made by 50% or more of the participants were further analyzed to understand if the object affordance was high, moderate or low. When an object has a high affordance, such as the apple for eating, regardless of the other objects in the image the participant always chose eating. Other objects, such as the knife, had a medium affordance. For example, if the knife was paired with an item that afforded cutting, then the participant chose cutting; however, if there was no object that could be cut, the knife did not elicit cutting. Other objects, such as the plate, had a low affordance and was rarely related to any of the activities listed.

The objects that had high affordance included apple (eating), pitcher (pouring), water bottle (drinking), shampoo bottle (squeezing), hairbrush (brushing), toothpaste (squeezing), soda can (drinking), hand towel (cleaning), sponge (cleaning), tomato (eating), and cereal box (eating). Objects with medium affordance were notebook (reading), scissors (cutting), mug (pouring), plate (eating and cleaning), bowl (pouring), spoon (eating), cereal box (pouring), and marker (writing). Objects with low affordance were toothbrush (brushing) and knife (cutting). The choices made by students and therapists were generally similar.

DISCUSSION

The results from this study showed that objects may have a high, medium, or low affordance, which will influence how they are chosen for specific activities. Object affordances can impact an individual's reactions to certain items and how they use them in activities (Bach, Nicholson, & Hudson, 2014). It would be beneficial for therapists to understand differences between object affordances when choosing objects to be used in therapeutic interventions. For example, if a therapist picks an object with low affordances, this study might indicate that additional objects would need to be provided to elicit the intended activity.

The comparison between the students and the therapists suggested that objects have inherent affordances that elicited similar activity choices. More than 50% of the respondents from each group associated the notebook with reading, the knife and scissors with cutting, and the mug and soda can with drinking. This suggests some object affordances may be widely recognized irrespective of exposure to therapy environments or intervention coursework. Bach et al. (2014) proposed the affordance-matching hypothesis, which describes how knowing an object's

characteristics, purpose, and one's previous experience with it, can influence an individual's action. However, there were still differences noticed in certain activities chosen for certain objects. Most of the objects in this case were objects with lower inherent affordances. However, the relationship between stroke therapy experience and object affordance is not completely clear and warrants further investigation.

This preliminary study will assist in guiding the field of robot assisted therapy; however, additional data from a greater number of practicing occupational therapists is required to ensure that the data obtained reflects realistic practice contexts. Additional data will also help to uncover trends and consistencies that are not visible yet based on current data collected.

This study had a few limitations. 1) Instructions might not have been clear. They were not displayed throughout the entire survey, which could have confused the participants 2) Gender, culture, and socioeconomic status could have also influenced the results of study, especially since the majority of the participants were female and Caucasian. 3) The objects were nominally labeled, which may have led to an assumption about what the object should be used for, although the majority of the objects were everyday items. 4) The mug was displayed as empty, so it was unclear if participants disregarded its affordance without anything inside of it. The soda can and water bottle did not have the same response as the mug, because it appears that participants assumed there was liquid inside 5) Instructions did not include the terminology "therapeutic activity" and therefore participants may have been using personal experience instead of clinical reasoning in their decision-making process.

As technology continues to be a growing part of therapeutic intervention, there is an increased need for research to understand the therapeutic process and how occupational therapists make decisions about objects. This understanding is needed to ensure the accuracy of robot assisted when using objects.

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