Representation of Movement for Robots with Personality: A Co-Design study with Small Groups of Children

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***Abstract*— We conducted a co-design study with small groups of children in which they were asked to create movements for block-like robots according the robots' personality. This study was done as part of a larger project entitled THE ROBOT–CREATIVITY PROJECT, whose goal is to create robots for groups of children to help boost their creativity through playful activities. 52 children (*M*=7.93 years old, *SD*=1.32, 48.1% female) participated in this study. They produced movements for six robot personalities along three axes: Extraversion, Openness to experience and Agreeableness. The produced movements were subsequently coded using the Laban Effort System. Based on 30% of the analazyed data, children chose to represent movements differently for different personality traits of the robot, providing a movement framework to develop robots for creativity stimulation.**

Keywords - Creativity, children, groups, social robots

I. INTRODUCTION

Social robots are envisioned to enter our daily environments in a variety of contexts, including homes, work, and educational spaces. To develop these robots, a multidisciplinary approach is often employed, bridging technological, psychological, and design perspectives [1]. This research approach has been used to study robots for children in educational contexts [2], [3], for elders with health care purposes [4], and for adults in collaborative tasks [5].

The vast majority of such Human-Robot Interaction (HRI) and social robotics research, studies aspects of interaction with these robots and deals exclusively with questions concerning one human and one robot. In contrast, with an increasing number of robots we can expect many scenarios in which *more than one person and more than one robot are interacting at the same time*, leading to a growing interest in multi-person multi-robot interactions. The present study is part of such a project, focusing on the interaction between groups of children and groups of robots. We are specifically interested in groups of robots that can boost the creativity of groups of children.

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Creativity is becoming an important and pervasive human ability [6] as societies are shifting from industrialized to creative economies. In these economies problem-solving skills and creative collaboration skills are indicators for growth [7]. In stark contrast to the increasing need for creativity, creative skills seems to decline during school age years in a phenomenon entitled the *"creativity crisis"* [8], [9]. We propose to use social robots as tools for supporting and nurturing creativity in young children, specifically targeting *social creativity* enhancement [10].

Social creativity is a relatively new concept that emphasises how human creativity arises in the interaction and collaboration with other individuals in a social-cultural context [11]. To develop a robot that can stimulate social creativity, it needs to enhance creativity and be social at the same time. As a result, we established two design principles for the development of such a robot: the development of a *social component* based on personality traits that will enable to personalise interactions between the robot and children; and a *creative component* in which the robot will make use of techniques for creativity enhancement during the interaction with groups of children. This paper is focused on the social component in which personality traits will enable the robot to display social behaviors, providing a way to personalise and humanize the social interaction with children.

To find social behaviors that make sense to the children we are working with, we set out to co-design these behaviors with the children involved. In the present study, small groups of children were involved in the design process of developing movements for the robot according to different personality traits. We used a co-creation activity to involve children as co-designers of the social component for the robot, specifically, the design of movements for different personality traits. Co-creation is a form of social creativity defined as a process that leads to the emergence of new meanings engendered by different processes such as improvisation in a group [12].

The involvement of small groups of children in the design process enabled them to generate ideas and think "outside the box" to solve the problem that was given to them, in this case to develop the robot's movements. Therefore, our co-design methodology is also intimately connected with the creativity processes that emerge in groups, which we are interested in as the goal of THE ROBOT–CREATIVITY PROJECT.

II. THE ROBOT-CREATIVITY PROJECT

THE ROBOT–CREATIVITY PROJECT's goal is to develop multiple social robots acting as tools to boost creativity in children. In the scope of this project we do not view robots as mere interactants with children, but instead as technological tools to foster creativity in children within the context of a school.

The use of robots to stimulate creativity relates to the fact that robots emerge as powerful interactive tools as they live in the same space as humans do, providing opportunities for physical interaction. Indeed, a study has showed that when comparing a social robot with a virtual agent, people seem to engage more with the robot, perceiving it as having more social influence and being liked more over the virtual agent [13]. In this project, we will design, develop, and evaluate groups of robots to enhance creativity in children between 7–8 years old. We envision these robots as non-humanoid artefacts that resemble toys for children to play with, having the potential to be conductors of creative thinking.

III. MOVEMENT AND PERSONALITY

The main contribution of this study was the involvement of children as co-designers of the robot behavior. In the following subsections we provide a theoretical framing of the concepts of movement and personality to underpin key-concepts of the study.

A. Pretend Play and Object Substitution

One of the skills that children acquire during their developmental stage is object substitution, or the ability to use an object to represent another. In order to do this, children acquire skills that allow them to separate the meaning of an object from the object itself, giving identities to objects other than their original ones [14], [15]. This is why children develop symbolic play, namely pretend play, in which a toy (or any other object) can represent something else rather than what it is (*e.g.*, a toy that has the form of a teddy bear can represent in fact a boy that is going to school) [16]. Additionally, children are capable of representing an object or a referent without the need for an actual substitute, using the ability to imagine it and to represent it using movements or gestures (*e.g.*, being able to develop acting skills in which they need to embody a given character) [17]. The major goal of this study was to involve children in the *design of movements that express personality traits for a robot* using low fidelity robot prototypes (see Figure 1). The movement or gestures that children perform with the robots are the symbolic representations that children hold of specific personality traits.

B. Movement and Narrative

When we think about *movement*, we imagine a *change in position* of either the whole or of a part of something or someone. Based on movements that are around us we tend to create our own story about us, with the goal of restoring or maintaining our sense of order. This occurs since humans are action centres that strive within bounds to create their own worlds and interpret reality. Indeed, humans have an urge to narrative and we even use narrative to describe movements of inanimate objects with the underlying requirement that we give agency to those objects [18]. A classic example of

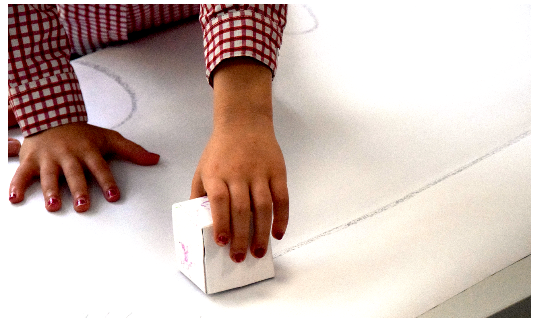

Fig. 1. Child interacting with the low fidelity paper prototype of a robot in the form of a cube.

narrative emergence through agency projection in movements was an experiment conducted by Heider and Simmel (1944), in which the perception of movement was studied by asking participants to interpret a movie-picture film in which three minimalist geometrical figures (a small and a large triangle and a disc) were shown moving in various directions and at various speeds (part of the film can be seen here: https://www.youtube.com/watch?v=VTNmLt7QX8E). Authors have concluded that the majority of the groups had interpreted the figures as animated beings, creating stories about them (*e.g.*, love stories) and almost no participant described the whole movie-picture film using factual geometrical terms [19]. This seems to show that humans not only are able to interpret human-like movement and attribute a meaning to it (*e.g.*, emotion attribution) [20], but are also able to project agency and create a narrative about movement of non-anthropomorphic and minimalist objects. The findings from Heider and Simmel (1944) have inspired our methodology decision of using the geometric form of a cube to serve as the robotic paper prototype that children in the study would move or, using narrative words, *animate*.

Many researchers have recognized the richness and importance of movements. Indeed, many forms of movement notation were developed as researchers became interested in having a widely and systematic language for describing movement so that it would be remembered and could be categorized [21]. From the existing notation movement systems, we highlight the Laban Movement Analysis (LMA) as it presents a promising way to model and analyze movement of robots [22], [23]. The LMA was developed by Rudolf Laban in the 1940's to record dance choreography [24]. It is a method for observing, describing, notating and interpreting human movement according to four categories:

Body: the way a body changes shape during movement;
Effort: the dynamic qualities and characteristics of how the movement is performed with respect to the inner intentions;
Shape: the manner in which the bodys structure changes during a movement;
Space: the interactions between the body and its environment.

TABLE I

PERSONALITY DIMENSIONS ACCORDING TO THE BIG FIVE MODEL OF PERSONALITY (LEFT COLUMN) [25]. ADAPTATION OF THE TERMINOLOGY FOR CHILDREN (RIGHT COLUMN).

Personality dimensions (and opposing poles)	Adaptation of terminology for children
Neuroticism (vs. Emotional stability)	-
Extraversion (vs. Introversion)	Social (vs. Shy)
Openness (vs. Closedness to experience)	Imaginative (vs. Flat)
Agreeableness (vs. Antagonism)	Kind (vs. Grumpy)
Conscientiousness (vs. Lack of direction)	-

C. Movement and Personality

Laban believed that through the application of the four categories of movement (*i.e*., body, effort, shape and space), one could, not only reach an understanding about the physical aspects of movements, but also about the psychological and emotional inner states [26], [27]. North (1972) completed Laban's thinking, hypothesizing correlations between personality and movement. She proposed that the Laban Effort system would be the categories of movement in which the individual's personality is most saliently perceived as it uses patterns and rhythms that are key for understanding inner states [28]. This hypothesis was later confirmed by some research, such as Levy's study (2003) [29]. Personality is a term used to describe relatively enduring styles of thinking, feeling and behavior that characterize an individual. It has been conceptualized from a variety of theoretical perspectives, providing different contributions for understanding individuals. For the purposes of developing a personality for a robot, we have relied on the Big Five Model of Personality, also entitled as the Five Factor Model developed by McCrae and Costa [30], and on the correspondent NEO Personality Inventory Revised (NEO PI-R). In this model, personality is described according to five factors (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience), each of these factors is a continuum with an opposing pole [25] (see Figure III-C, left column) encompassing several traits. Thus, *extraversion* corresponds to a dimension that includes traits such as sociable, talkative, assertive, energetic; *agreeableness* relates with good-natured, cooperative and trustful characteristics; *conscientiousness* concerns with a disposition for control, self-disciplined, and responsible; *neuroticism* includes traits such as nervous, unstable, and insecure; and *openness to experience* with intellectual, imaginative, insightful, and curious traits [31]. As we have mentioned, movement appears to be related with inner states. To achieve our goal in creating movement for a robot, we relied on three personality dimensions to instruct children to build movements for. The chosen dimensions were *extraversion and agreeableness* because they are the ones that are more related to the social facets of personality and, therefore, the ones that could be better captured in a social interaction with a robot, as we expect the robot to be able to maintain a social interaction with groups of children. In addition, we also selected *openness to experience* because it includes traits related to creativity.

TABLE II

LABAN EFFORT SYSTEM FOR MOVEMENT QUALITY [32].

Laban Effort System	Indulging	Fighting
Space	Indirect	Direct
Weight	Light	Strong
Time	Sustained	Quick
Flow	Free	Bound

IV. CO-DESIGN MOVEMENTS OF PERSONALITY TRAITS FOR ROBOTS

Co-design is an approach that actively involves users in the design process, to ensure that the product that is being developed meets their needs and is useful [33]. From the different roles that children can have as co-designers of new technologies [34], we chose to involve them as design partners for the design of movements for robots. Moreover, co-creating movement for a robot in small groups enable children to connect with creative experiences, such as idea generation and problem solving in group context.

In this study, children were invited to represent 2 types of movements for the robot: (1) *social movement*, which refers to how a robot moves when it meets another robot; (2) *alone movement* which refers to how a robot moves when it is walking alone. The movements that children created for each personality dimension were analyzed using the LMA.

A. Sample

A total of 52 children participated in this study (M = 7.93 years old, SD = 1.32; 48.1% female, 51.9% male) conducted in a classroom of School Infante Sagres in Lisbon, Portugal. Children performed the activity of developing personality for a robot in groups of 3-5 children. The study had two pilot sessions, each session comprised four children. These pilot sessions provided insights about the activity that children performed and enabled us to refine and adapt it according to our research goals. Thus, the main study was comprised of 44 children, distributed in 9 groups of 4 children, 1 group of 3 children and 1 group of 5 children. The intended size for all the groups was of 4 children, but due to a child that got ill one of the group performed the activity with only 3 children, and another group performed the activity with 5 children as we did not wanted to exclude any children that had signed up for the activity. Inclusion of children in the study was dependent on parents' consent, which was signed prior to the study.

B. Method and material decisions

Paper prototypes of a robot in the form of cubes were used. The prototypes were made using origami techniques and each cube was built with a mechanism that integrates a crayon inside so that children could represent the movements of the robot *by drawing them* in large paper sheets used as playgrounds (see Figures 1 and 2). To embed a crayon in one of the cube faces was a design methodology choice with a double intention. Firstly, by having a crayon we were able to collect physical representations of the movement that children made (in this case, the drawn trajectory of the movement in paper sheets) and this was important to enable movement analysis; secondly, we wanted to motivate children to represent the robot's movements in a 2D space, avoiding movements in a 3D plane (such as flying, jumping). This was an important restriction, since movements in a 2D plane enable to collect data for later simulate and model the movements for robot. Additionally, a video camera was used to record the interaction so that the flow and weight of the movement could be analyzed.

C. Procedure

This study was performed in the classroom with children in groups of 3-4 children which were previously chosen by their teachers. Each session lasted around 1:00-1:30h and the procedure for the activity unfolded according to the following three stages:

Ice breaking: The first stage was concerned with breaking the ice and make children feel comfortable with the two researchers in the room. In the ice breaker activity we used a dice of cards with different animals that were randomly distributed on the floor. All participants and researches chose an animal that they thought sharing similarities with them and explained heir choice to the group. This enabled the researchers and the children to get to know each other by sharing something about themselves. In order to conduct a successful co-design session with groups of children and set expectations, we have applied the CHECk tool [35] in which we explained children their role as design partners in a co-design session. The researcher, who was a psychologist, moved to the next stage when felt children were comfortable and relaxed within the group and ready to start the next activity.

Personalities' passerelle: As the ultimate goal is to collect children's representation of movements for different personality traits, we developed an activity to ensured that all children would understand the meaning of the three dimensions of personality. This activity was called "personalities' passerelle" and makes use of a bodystorming technique to prime children about the personality dimensions. A set of instructions related with personality were given to children *e.g.*, *"imagine you are now very shy, how would you walk now?"* Children were in a circle and start moving in the classroom in a way that would express themselves. Because children could not use words, they use movements of their bodies and also sounds. The rule of no-words was set as the main activity of moving, given that a robot may not imply verbal content. Next we instructed children as follows: *"Now you are grumpy, how do you walk now? Remember that you cannot talk."*, *"How would you like to express to others that you are grumpy"* At the end of the activity

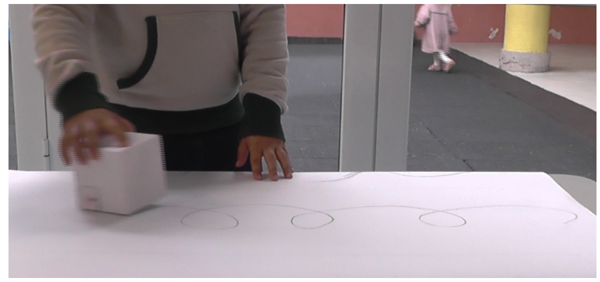

Fig. 2. Example of a trajectory performed by a child.

children knew the meaning of the different personality dimensions they could represent on the robots, namely extraversion, openness to experience and agreeableness. As this terminology is very unfamiliar to children, we adapted it and used other trait adjectives *social and shy* to represent extraversion and introversion, *imaginative and flat* for openness and closeness to experience, and *kind and grumpy* for agreeableness and antagonism (see Figure I). This terminology was used throughout the activity.

Movement production At this stage, children were randomly assigned to produce movements for one of the personality dimensions using a low fidelity robot prototype in the form of a cube. Thus, children adapted the expression of the movements that they have performed with their own body to a non-humanlike robot, exploring how this body constrain could nevertheless express a personality trait. Each child was invited to produce the movement of one of the three personality traits: extraversion (social and shy); openness to experience (imaginative and flat), agreeableness (kind and grumpy). As mentioned, children were instructed to produce 2 types of movement: *social movements* and *alone movements*. Since each child was assigned to one personality trait (*e.g.*, extraversion) that considers two poles (*e.g.*, in the case of extraversion, the two poles are being *social* and *shy*, each child produced a total of 6 different movements (3 movements for each pole).

V. Analysis, Results and Discussion

This study enabled the collection of two types of data sets: paper sheet drawing productions of robot movements and recordings of the movement production through the use of a video camera. Our goal was to analyze the produced movements that children have performed with the low fidelity robot prototype using both data set sources according to the Laban Effort System described below.

A. Laban Effort System for movement analysis

We relied on LMA to analyze the movements produced by children for the robot prototype. As explained in Section III-B, LMA is composed of four categories of movement (body, effort, shape, and space) [24]. Since our interest was to analyze children's represention of personality traits using movement, we selected the Laban Effort System to perform the analysis as this is the category of LMA that relates with the expression of inner states through movement. The Laban Effort System is composed of four motion factors: *space, weight, time and flow*. These four factors describe the quality of the continuum movement through how resistant the movement appears to be: if the movement appears to have no resistance (named as *indulging*) or if it appears to be a resistant movement (named *fighting*). The organization of this coding scheme is detailed below (see also Table II):

Space (indirect-direct) Defines the spacial orientation of the movement; *indirect:* the front of the low fidelity robot prototype changes different orientations are considered such as side- back-wards; *direct:* the robot acquires always the same spacial orientation and never changes it until the movement is over.

Weight (light-strong) Defines how "heavy" the movement appears to be; *light:* the movement appears to be effortless, being less influenced by gravity; *strong:* the movement if performed with power or force.

Time (sustained-quick) Defines the speed-related aspect of the movement; *sustained:* the movement is made by making lingering movements; *quick:* the movement is performed by making hurried or urgent movements that are less time consuming.

Flow (free-bound) Defines the amount of control of the movement; *free:* free movements occupy space and can be messy; *bound:* the movement is careful and controlled.

We have analyzed 30% of the collected data (a total of 78 movement productions) which is reported in this document, and the remaining data is under analysis. Each movement was manually coded using the QSR International's NVivo 11.4.1 Software, taking into account the Laban Effort System (see Table II). The analysis was performed by analysing the videos that recorded the movement performed by children (see the frame in one of the videos in Figure 2).

B. Results and discussion

In this section we discuss the results. Figure 3 shows movements that children created, clustered by personality trait (*e.g.*, extraversion), pole (*e.g.*, shy and social) and movement type (*i.e.*, graphs on the left represent what we have called "alone movement", whereas graphs on the right represent "social movement"). Considering the three personality traits (Extraversion, Openness to experience and Agreeableness), results have shown that children were able to perceive and represent a variety of movements for different personalty traits in a robot. This can be seen by looking at the changes in frequency displayed by the geared graphs in Figure 3: The more away from the center of the gear graph, the more frequent the movement was. More specifically, we can see that the poles for different personality traits were represented with different movements, *e.g.*, if we consider Extraversion, we can see that a *shy robot* moves slowly, adopting careful and controlled movements (Bound and Sustained are the most frequent movement types that represent this result) and not exploring much the environment around it (from the same graph, we can see that Direct frequently appears, being the indicator if this result). On the other hand, a *social robot* performs expansive, effortless and free movements, but at a slow pace (we can see high frequencies for Light, Free and Sustained movements). Regarding Openness to experience, an *imaginative and a flat robots* were represented similarly: careful and controlled, effortless and slow movements were produced (Bound, Sustained and Light movements, according to the graph), also not exploring much the surrounding space, and looking always to the front (Direct movement). Finally, for Agreeableness, a *grumpy robot* was perceived moving fast with force and powerful movements, with movements that

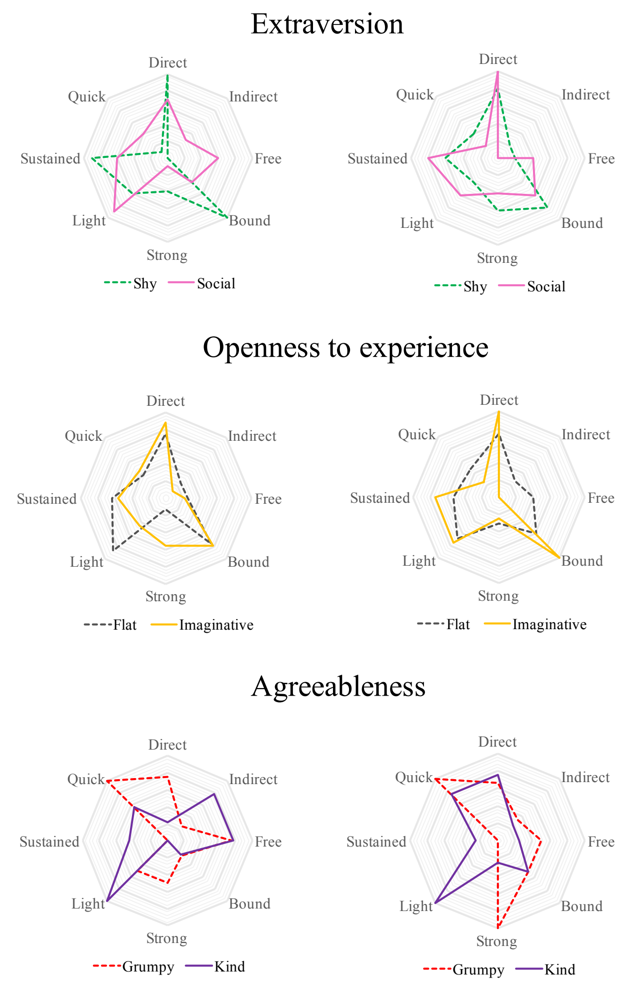

Fig. 3. **Gears of personality movement for robots.** The movements are shown for the *alone movement* (graphs on the left) and *social movement* (graph on the right) types, according to poles of three personality traits (Extraversion, Openness to experience and Agreeableness) using the Laban Effort System. The graphs should be interpreted the following way: *Extraversion* personality trait is composed of the poles *shy* and *social*. In the alone movement constellation, a *shy robot* moves in a more direct space, sustained time and bound flow; whereas in social movement constellation, direct space and bound flow are what best describes its movement.

were not necessarily controlled (Quick, Strong and Free). A *kind robot*, however, moves effortlessly (Light movement).

When looking at the different movements that children produced for the alone movement (graphs on the left) and the social movement (graphs on the right), it can be seen that the robots seem to move in the same way when they are alone or in a social context if they belong to the same personality trait. We can see this by comparing, *e.g.*, the shy robot from the graph on the left with the right and conclude that the same movement types are made, although with slightly different frequencies and appearing to be more creased when the robot is alone than in a social context; the only exception is the *kind robot* which explores the surroundings around it by looking at various directions when it is alone, but when in a social context he refrains from doing so and becomes engaged with one spacial direction only, which is is facing towards the other robot.

VI. WORK IN PROGRESS AND FUTURE GOALS

The next steps concerns the analysis of the remaining data to understand fully how children represent movement for robots with different personalities. The knowledge gathered will enable modelling these movements and build different robots for children to play with. We will make use of the LMA to develop different movement notations for robots (*e.g.*, by defining how light/heavy the movement appears to be, the speed of the movement, etc). As the ultimate goal of our research is to have multiple robots interacting with multiple children to boost their creativity, we plan on relying on robots with different personalities to convey different creativity strategies for creativity enhancement. Additionally, we plan on validating the different movements corresponding to different personality traits with children in a future study.

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REFERENCES

[1] A. V. Libin and E. V. Libin, "Person-robot interactions from the robopsychologists' point of view: The robotic psychology and robotherapy approach," *Proceedings of the IEEE*, vol. 92, no. 11, pp. 1789–1803, 2004.

[2] O. Mubin, C. J. Stevens, S. Shahid, A. Al Mahmud, and J.-J. Dong, "A review of the applicability of robots in education," *Journal of Technology in Education and Learning*, vol. 1, pp. 209–0015, 2013.

[3] F. B. V. Benitti, "Exploring the educational potential of robotics in schools: A systematic review," *Computers & Education*, vol. 58, no. 3, pp. 978–988, 2012.

[4] H. Robinson, B. MacDonald, and E. Broadbent, "The role of healthcare robots for older people at home: a review," *International Journal of Social Robotics*, vol. 6, no. 4, pp. 575–591, 2014.

[5] M. A. Goodrich and A. C. Schultz, "Human-robot interaction: a survey," *Foundations and trends in human-computer interaction*, vol. 1, no. 3, pp. 203–275, 2007.

[6] L. W. Anderson, D. R. Krathwohl, and B. S. Bloom, *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Allyn & Bacon, 2001.

[7] R. Florida, "The rise of the creative class and how it's transforming work, leisure, community and everyday life (paperback ed.)," 2004.

[8] K. H. Kim, "The creativity crisis: The decrease in creative thinking scores on the torrance tests of creative thinking," *Creativity Research Journal*, vol. 23, no. 4, pp. 285–295, 2011.

[9] M. Csikszentmihalyi, "Flow and the psychology of discovery and invention," *HarperPerennial, New York*, vol. 39, 1997.

[10] G. Fischer, E. Giaccardi, H. Eden, M. Sugimoto, and Y. Ye, "Beyond binary choices: Integrating individual and social creativity," *International Journal of Human-Computer Studies*, vol. 63, no. 4, pp. 482–512, 2005.

[11] M. Csikszentmihalyi and K. Sawyer, "Creative insight: the social nature of a solitary moment," *The Nature of Insight*, 1995.

[12] E. Giaccardi, "Principles of metadesign processes and levels of co-creation in the new design space," 2003.

[13] A. Powers, S. Kiesler, S. Fussell, and C. Torrey, "Comparing a computer agent with a humanoid robot," in *Human-Robot Interaction (HRI), 2007 2nd ACM/IEEE International Conference on*. IEEE, 2007, pp. 145–152.

[14] L. S. Vygotsky, "Play and its role in the mental development of the child," *Soviet psychology*, vol. 5, no. 3, pp. 6–18, 1967.

[15] H. Werner and B. Kaplan, *Symbol formation*. Psychology Press, 2014.

[16] M. Tomasello, T. Striano, and P. Rochat, "Do young children use objects as symbols?" *British Journal of Developmental Psychology*, vol. 17, no. 4, pp. 563–584, 1999.

[17] C. J. Boyatzis and M. W. Watson, "Preschool children's symbolic representation of objects through gestures," *Child development*, vol. 64, no. 3, pp. 729–735, 1993.

[18] M. Murray, "Narrative psychology," *Qualitative psychology: A practical guide to research methods*, pp. 111–131, 2003.

[19] F. Heider and M. Simmel, "An experimental study of apparent behavior," *The American Journal of Psychology*, vol. 57, no. 2, pp. 243–259, 1944.

[20] H. G. Wallbott, "Bodily expression of emotion," *European journal of social psychology*, vol. 28, no. 6, pp. 879–896, 1998.

[21] M. Abbie, "Movement notation11delivered at the xiii biennial congress of the australian physiotherapy association, brisbane, august, 1973." *Australian Journal of Physiotherapy*, vol. 20, no. 2, pp. 61–69, 1974.

[22] M. Sharma, D. Hildebrandt, G. Newman, J. E. Young, and R. Eskicioglu, "Communicating affect via flight path exploring use of the laban effort system for designing affective locomotion paths," in *Human-Robot Interaction (HRI), 2013 8th ACM/IEEE International Conference on*. IEEE, 2013, pp. 293–300.

[23] H. Knight, "Expressive motion for low degree-of-freedom robots," *Doctoral Thesis*, 2016.

[24] R. Laban, "Modern educational dance. revised by l," *Ullmann. London: MacDonald and Evans.(First published 1948)*, 1963.

[25] P. T. Costa and R. R. McCrae, "Neo pi-r professional manual," *Odessa, FL: Psychological assessment resources*, 1992.

[26] I. Bartenieff, *Effort-Shape analysis of movement: The unity of expression and function*. Albert Einstein College of Medicine, Yeshiva University, 1965.

[27] I. Bartenieff and D. Lewis, *Body movement: Coping with the environment*. Psychology Press, 1980.

[28] M. North, *Personality assessment through movement*. Macdonald and Evans, 1972.

[29] J. A. Levy and M. P. Duke, "The use of laban movement analysis in the study of personality, emotional state and movement style: An exploratory investigation of the veridicality of" body language"." *Individual Differences Research*, vol. 1, no. 1, 2003.

[30] R. R. McCrae and P. T. Costa Jr, "Personality trait structure as a human universal." *American psychologist*, vol. 52, no. 5, p. 509, 1997.

[31] O. P. John and S. Srivastava, "The big five trait taxonomy: History, measurement, and theoretical perspectives," *Handbook of personality: Theory and research*, vol. 2, no. 1999, pp. 102–138, 1999.

[32] R. Laban and F. Lawrence, "Effort: A system analysis, time motion study," *London: MacDonald & Evans*, 1947.

[33] A. Melonio and R. Gennari, "Co-design with children: the state of the art," Technical report, KRDB Research Centre Technical Report, Tech. Rep., 2012.

[34] A. Druin, "The role of children in the design of new technology," *Behaviour and information technology*, vol. 21, no. 1, pp. 1–25, 2002.

[35] M. Van Mechelen, G. Sim, B. Zaman, P. Gregory, K. Slegers, and M. Horton, "Applying the check tool to participatory design sessions with children," in *Proceedings of the 2014 conference on Interaction design and children*. ACM, 2014, pp. 253–256.