Kastamonu Education Journal, 2023, Vol. 31, No:3, 386-403
doi: 10.24106/KEFDERGİ-2022-0033

| Research Article |

Visual Appearance Features of Sign Language Avatars

İşaret Dili Avatarlarının Görsel Görünüm Özellikleri

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Keywords

1. 3D avatar design
2. Sign language
3. Educational agents

Anahtar Kelimeler

1. 3B avatar tasarımı
2. İşaret dili
3. Eğitsel ajanlar

Received/Başvuru Tarihi
25.05.2022

Accepted / Kabul Tarihi
17.05.2023

Abstract

Purpose: 3D Sign language avatars communicate with individuals in digital environments, like educational agents. However, while designing educational agents, the target group comes to the fore. In the literature, it is seen that the visual appearance features that should be considered in the creation of avatar designs are specified in diverse ways. Main goal of this study is to evaluate the sign language avatars' visual appearance features in the literature and applications within the framework of educational agents.

Design/Methodology/Approach: In this study, seventy-nine different sign language avatars' images were evaluated within the framework of visual appearance features. Seven category and fifteen features were evaluated by four field experts through focus group discussions.

Findings: In the evaluation, seven important categories were determined in avatar visual appearance. It is seen that the eye and head designs of avatars are generally designed in normal size. If an iconic design process is being carried out, eye, head, arm, and finger visual appearances should be designed larger than normal. If a realistic design process is carried out, eye, head, finger, palm, and arm visual appearances should be designed in normal sizes.

Highlights: When designing sign language avatars, the upper body should be visible. In addition, what the target group will be affects the gender and iconicity of the avatar. Avatar should be designed simply so that individuals do not overload their visual channel. Also, different visual appearance features should be considered for iconic or realistic avatars. In addition to this, it is recommended that the hand and head sizes should be bigger than normal in order to understand the signs and non-manual signs more clearly.

Öz

Çalışmanın amacı: Üç boyutlu işaret dili avatarları eğitsel ajanlarda olduğu gibi dijital ortamlarda kullanıcı ile iletişim kurar. Eğitsel ajanlar tasarlanırken hedef grup etkili bir kriter olarak dikkate alınır. Literatürde avatar tasarımlarının oluşturulmasında dikkate alınması gereken özellikler çeşitli şekillerde ifade edilmektedir. Bu çalışmanın amacı ise işaret dili avatarlarının görsel görünüm özelliklerinin belirlenen kriterlere göre değerlendirilmesidir.

Materyal ve Yöntem: Bu çalışmada, yetmiş dokuz farklı işaret dili avatarına ait görseller, görünüm özellikleri çerçevesinde değerlendirilmiştir. Yedi kategori ve onbeş özellik, dört alan uzmanı tarafından odak grup görüşmeleri ile değerlendirilmiş ve kategorileştirilerek tartışılmıştır.

Bulgular: Değerlendirmede avatarların görünüm özelliklerinin değerlendirilmesi için yedi kategori belirlenmiştir. Avatarların göz ve kafa tasarımlarının genellikle normal ölçülerde tasarlandığı görülmektedir. İkonik bir avatar tasarımı yapılıyorsa göz, baş, kol ve parmak boyutları normalden daha büyük tasarlanmalıdır. Gerçekçi bir avatar tasarımı yapılıyorsa göz, baş, parmak, avuç içi ve kol boyutları normal ölçülerde tasarlanmalıdır.

Önemli Vurgular: İşaret dili avatarları tasarlanırken, vücudun üst kısmı görünür olmalıdır. Bunun yanında hedef grubun özellikleri avatarın cinsiyetine ve ikonikliğine etki etmektedir. İşaret dili avatarı bireylerin görsel kanalında aşırı yükleme yapmaması için sade tasarlanmalıdır. Ayrıca ikonik veya gerçekçi avatarlar için farklı görsel görünüm özellikleri dikkate alınmalıdır. Bunun yanında işaret ve el dışı işaretlerin daha net anlaşılabilmesi için el ve kafa boyutlarının büyük olması önerilmektedir.

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Citation/Alıntı: Atasoy, M., Şılbır, L., Fiş Erümit, S., Bahçekapılı, E., Yıldız, A., & Karal, H. (2023). Visual Appearance Features of Sign Language Avatars, Kastamonu Education Journal, 31(3), 386-403. doi: 10.24106/KEFDERGİ-2022-0033

INTRODUCTION

Individuals of deaf society usually communicate among themselves and with those who know sign language by using sign language instead of written or spoken language (Adalı, 2019; Dikyuva et al., 2015; Xu, 2013). Sign language has a structure with its own grammar rules, finger alphabet, hand, face, and gestures (Karaca & Görgünoğlu, 2011; Kubuş, 2008; Solina et al., 2011). It is known that deaf individuals have serious problems in understanding written texts (Escudeiro et al., 2015; Solina et al., 2011). In addition, it is stated that deaf individuals use limited options to communicate with individuals who do not know sign language. These are paying attention to gestures, using a sign language translator, writing, lip reading, using slow sounds for those who have hearing residue and using assistive technologies (Gugenheimer et al., 2017).

When the sign language studies are examined, different computer-based technologies such as transforming text and voice into Gesture Mark-up Language (Brour & Benabbou, 2019; Eryiğit et al., 2016; Kayahan, 2019; Raghavan et al., 2013), three-dimensional (3D) avatars that translate text into sign language (De Martino et al., 2017; Ebling & Glauert, 2016; Gibet et al., 2016; Karaca, 2018; Vesel & Robillard, 2013), technologies that transfer the signs to the computers with image processing (Mahesh et al., 2017), sign language robots (Baranwal et al., 2017; Gürpınar et al., 2020; Meghdari et al., 2019; Özkul, 2015), dictionaries for sign language words (Hilzensauer & Krammer, 2015; Makaroğlu & Dikyuva, 2017; Milli Eğitim Bakanlığı, 2019; Solina et al., 2011) can be seen. By combining technologies such as gesture mark-up language, image and sensor detection, 3D environments, and sign language dictionaries, words or sentences can be animated with an avatar within the framework of human computer interaction. Studies are carried out with avatar technologies that provide sign language translation for different languages (Brock et al., 2018; De Martino et al., 2017; Li et al., 2014; Yousaf et al., 2018). Avatar studies generally focus on the methods of translation of spoken language into sign language, the systems and software used, however, the visual appearance of sign language avatars remain in the background. Avatars, which model sign language in 3D environment, communicate with individuals in digital environments, like educational agents. Educational agents are simulated human-like virtual characters to enhance the individual learning of the students (Z. Chen & Chen, 2014; Chou et al., 2003; Öngöz et al., 2015). Educational agents support learning in terms of emotional, social and cognitive aspects (Hong et al., 2014). Educational agents motivate students in the learning environment (Chin et al., 2016; Dinçer & Doğanay, 2017; Guo & Goh, 2015; Heidig & Clarebout, 2011; van der Meij et al., 2015) and support effective learning (Baylor & Kim, 2009; Goldberg & Cannon-Bowers, 2015; Grivokostopoulou et al., 2020; Lewis Johnson & Lester, 2018a). From this point of view, educational agents can provide functions such as warning, feedback and guidance (Gulz & Haake, 2006), while avatars can animate these functions in a virtual environment (Michael Gerhard, 2003). Gerhard, Moore, and Hobbs (2001) stated that the avatar is a character that reflects the identity of the person in virtual environments. Just as human body features are important in the formation of personality in the real world, avatar features in virtual environments are important as in the formation of virtual personality (Donath, 2001). Avatar represents the visual appearance characteristic of educational agents. In addition, an educational agent can provide feedback to the user thanks to its functions. From this point of view, avatars can be defined as the shape of educational agents.

When designing educational agents, determining avatars according to the target group and structural features that educational agents have are considered important in achieving the desired success (Z. Chen & Chen, 2014). For this reason, studies have been carried out on how the visual appearance features of the avatar such as age, gender, character should be (Z. Chen & Chen, 2014; Öngöz et al., 2015). Yılmaz and Kılıç Çakmak (2011) stated in their study that avatar's personality, ability of movement, gestures and facial expressions, emotional expressions, dialogue and speech features used in educational agents are significant. The literature emphasizes that the visual appearance features of avatars used in sign language studies are effective in the perception of signs (Adamo-Villani et al., 2016; Jen & Adamo-Villani, 2015). Considering the studies on avatar visual appearance used in educational agents, it is important to reveal the visual appearance criteria for sign language avatar design.

Visual Appearance Features of Pedagogical Agents

Agents are frequently used in mathematics, science, foreign language, and culture (Lewis Johnson & Lester, 2018b). Learning environment designers develop pedagogical agents that monitor students' problem-solving activities and respond through different channels. These agents have several types in different settings. İzmirli, Kırmacı, and Kahraman (2017) list these types as smart agents, interface agents, assistant agents, information agents, evaluation agents, pedagogical agents, advising agents and expert agents depending on the roles they play.

Some studies on avatars used as educational agents focused on the effects of avatars being remarkable in terms of design on the user (Gulz & Haake, 2006; Haake & Gulz, 2008; Sutcliffe & Al-Qaed, 2007). Nowak and Rauh (2005) stated that users prefer human-like avatars rather than non-human avatars (animals, robots, etc.) and that such avatars are more attractive and reliable. In addition, realistic human-like avatars increase social interaction and female avatars are preferred more than male avatars (R. F. Khan & Sutcliffe, 2014).

In the literature, the design features of avatars have been studied under different titles in many studies. Gulz and Haake (2006) stated that visual presentation, face, body and costume design and iconic level are important for avatar design. Visual representation is expressed by line thickness, drawing angle and line style in 2D avatars, while in 3D avatars it is addressed with the features of shape, texture, lighting, surface, shading and animations (Gulz & Haake, 2006). On the other hand, Haake (2009), gathered the avatar features under three topics: basic model, physical features, and graphic style. The basic model is classified as

human, animal, creature, inanimate object, fantasy-science fiction, or a combination of these. Physical features are classified as body shape, face shape, skin color, hairstyle, haircut, dress, and accessories. Finally, the graphic style is classified as iconic and detail levels. Yılmaz and Kılıç Çakmak (2011) classified avatar features as physical appearance, movement, voice, facial expressions, dialogue and speech, and emotional expressions. Avatars have different body structures and can be designed as tall, medium, and short, or fat, normal, and thin. In addition, the features as hair color, hair length, eye color, eye shape, tooth structure, ratio of hands and feet to body size, nose structure of avatars may vary depending on the content of the software and focus group (Yılmaz & Kılıç Çakmak, 2011). Ducheneaut et al. (2009), examining the customizable avatars in games, emphasizes the importance of hair and its role in determining the identity of the person besides many features.

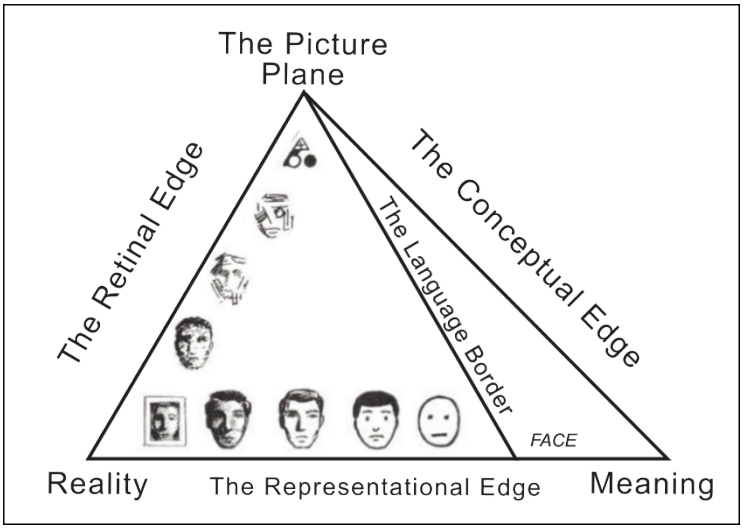


Figure 1. The Transition of Visuals Between Reality, Abstraction (The Picture Plane) and Meaning (Mccloud, 1993)

Avatars can be designed as 2D, and 3D form. 3D avatars are classified as photorealistic, iconic or abstract (Sloan, 2015). A similar classification explains the transition between reality, abstraction and meaning of visuals by McCloud (1993) with the "Big Triangle" scheme (Figure 1). In McCloud's triangle, avatars are represented on the left in their most realistic form, and as they move to the right, they change to their most iconic form. The most iconic avatar changes to a semantic expression, or concept, when it goes beyond the language border. For example, when we examine a human face, there is a real photograph on the far left, a face drawing of a stylized character in the middle, a face emoji on the far right, and the word itself outside the language border. While the actual photo represents a person, the far-right face emoji and the word “face” outside the language border represent much more people. Similarly, Gulz and Haake (2006) expresses the transition between 2D and 3D iconic and realistic avatars with the visual in Figure 2. Manning (1998) states that a highly realistic avatar will represent only one person and therefore cannot have a widespread effect. The greater the iconicity of an avatar, the greater its meaning and influence (Mccloud, 1993). For this reason, 3D iconic (lower middle region of the triangle) avatars with high representation degree can be accepted by many people compared to the realistic one. Besides, realistic avatars can create an "uncanny valley" effect (Mori et al., 2012). For example, humanoid avatars that are remarkably close to reality have a negative effect on users.

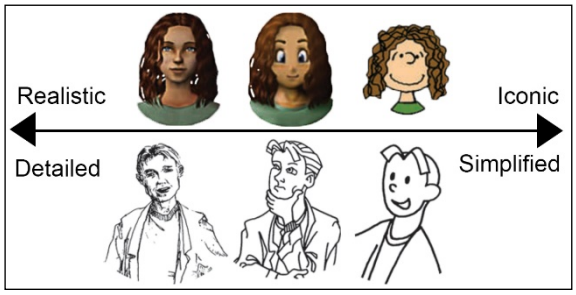


Figure 2. Iconic, semi-iconic and realistic image, adapted from Gulz and Haake (2006)

There are six basic emotions in the display of facial expressions: happiness, anger, surprise, sadness, disgust and fear (G. D. Chen et al., 2012). Nguyen and Canny (2009) stated that it is necessary to use facial expressions, hand and body movements and voices in order to add empathic features to the avatars. Facial expressions of avatars are important criteria for users (Clark & Choi, 2005). Additionally, interface designs with emotional facial expressions increase positive emotions and facilitate the recall of information (Uzun & Yıldırım, 2018). Also, the smiling welcome and farewell of the avatar and empathic responses create positive feelings about the software.

Another feature that is considered important in educational avatars is the face design. Face plays a fundamental role in attracting the attention of learners (Gulz & Haake, 2006; Uzun & Yıldırım, 2018). When educational avatars are examined, baby-faced avatars are more naive, honest, affectionate, and empathetic than other avatars. It has been stated that a face looking

downwards with eyes looking upwards expresses innocence and vulnerability (Gulz & Haake, 2006). Another important feature is neutral facial expression. People with a slight smile and a neutral facial expression in the resting position are viewed more positively. People with this type of facial structure are perceived as friendly and gentle (Branham, 2001; Gulz & Haake, 2005). However, people with low eyebrows, thin lips and a pulled mouth appearance are perceived as dominant, threatening, and aggressive. Such faces are not preferred in educational avatar designs (Gulz & Haake, 2006).

Body and costume design is another key factor in an avatar, and it plays an active role in communication. Therefore, the designs of the head, cheeks, mouth, eyes, hands, legs, and arms related to the costume or body structure should be emphasized separately. The three main body types defined by Sheldon et al. (1940) as thin, muscular and fat are still accepted today. Although muscular people are considered to be more attractive, healthy, courageous, competitive, and adventurous, they are seen as less knowledgeable, intolerant and temperamental (Ryckman et al., 1991).

The features mentioned above also vary according to gender. While human avatars are more interesting and reliable (Nowak & Rauh, 2005), female avatars are preferred more than male avatars (R. F. Khan & Sutcliffe, 2014). Considering that gender is one of the important variables for avatars, the color, shape, purpose and meaning of the clothes also differ according to gender.

Based on the above literature, Table 1 shows the features used in avatar designs of an educational agent. In addition, sub-features of each feature encountered are presented.

Table 1. Features of educational agents.

Educational Agent Features	Educational Agent Sub Features
1. Physical (Personal) Appearance	Gender
	Height
	Weight
	Hair color
	Hair length
	Head size
	Arm, hand, and finger sizes
	Facial structure
	Eye shape
	Eye color
	Tooth
	Eyebrows
	Nose
2.Moving Parts	Foot, knee, waist, back, shoulder, neck, head, arm, hand, finger, face
3.Communication	Facial (emotion) expressions, verbal communication
4.Iconicity	Realistic, iconic, abstract
5.Graphical Style	Line style, line direction, line shape
	Shape, texture, lighting, surface, shading
6. 2D and 3D	2D character, 3D character
7.Clothing and Accessories	Clothing type, clothing color, accessories

According to Table 1, seven basic features in the design of an avatar are specified. Accordingly, physical appearance is defined by gender, height, weight, hair color, hair length, size of body organs such as hands, feet, head, face shape, eye shape and eye color, teeth, eyebrows, and nose structure. In addition, moving parts such as foot, knee, waist, back, shoulder, neck, head, arm, hand, finger, face, are needed in avatars for more effective communication. Animated avatars provide a more flexible and impressive environment for individuals, especially by using body language, gestures, and facial expressions. Communication channels are also examined in educational avatars. Communication includes facial expressions and verbal communication elements that can express all emotions. Another feature, iconicity is an important feature in designs and expresses the change of avatar from reality to abstract. Iconicity has subcategories as realistic, iconic, and abstract. Graphical style refers to the drawing or modeling features of avatars. In addition, avatars can be used in two or three dimensions depending to the environment. Finally, considering the characteristics of the target audience, it is seen that the clothes in the avatars can be differentiated by type, color, and accessories.

Sign Language Avatars

Avatars are an important tool for converting texts into 3D sign language animations (Bouzid & Jemni, 2020; Do Amaral et al., 2011; Escudeiro et al., 2015). With the development of the entertainment and game industry in the virtual environment, advanced modeling and animation tools are emerging. Many animated avatars prepared with open-source tools, can be used for free. These avatars developed for the game industry are used in many studies on sign language. These studies aim to animate the sign language with sign language grammar and sign animations. Situations such as insufficient information on sign language grammar rules and sign language archives to be analyzed (Kaur & Kumar, 2016; N. S. Khan et al., 2015), the difficulty of analyzing the complex structure of sign language (El-Gayyar et al., 2016) and the situation of avatars not making or unable to make the movements of the external signs made with the mouth, eyebrows and eyes (Ebling & Glauert, 2016; Gonçalves et al., 2020) are some of the problems encountered in avatar-oriented sign language studies.

Considering the design problems and limitations of sign language; Avatar design studies can facilitate the integration of deaf people with avatars, social communication, and comprehensibility of sign language. In the studies examined, it is seen that while developing educational agents, the tasks and general characteristics of the agents were focused on (Gulz & Haake, 2006), but the avatar visual appearance of the agents were ignored. From this point of view, this study will fill this gap in the literature by thoroughly examining the visual features of sign language avatars.

METHOD

This study was conducted based on qualitative research approach using the document analysis method. Document analysis is a qualitative research method aimed at extracting meaning and generating detailed information from both printed and electronic documents. (Corbin & Strauss, 2008). This study was carried out in three-stage within the framework of this method. In the first stage, a review of the literature was performed to create an evaluation form for avatar design features. In the second stage, avatars in both sign language studies in the articles and the mainstream application stores were determined by the literature review method. Finally, the determined avatars were evaluated based on the avatar design features form.

Study Group

In this study, five experts in the field of educational technology are involved. The researchers have at least a decade of experience in educational technology and possess extensive project experience in developing technology supported educational materials for the deaf. Within this scope all researchers contributed to the process of literature review and the determination of avatars. In addition, the determined avatars were evaluated by the researchers in the study group with the focus group study method.

Data Collection

A systematic literature review was conducted to determine the avatar design features. Search words ("pedagogical agent design" OR "educational agent design" OR " pedagogical avatar design " OR " educational agent design") were used for scanning. As a result of the search, 445 articles were found. Examination of these articles, 23 articles were found related to design features. The avatar design features in these articles were examined and similar features were brought together. Research on avatars visual appearance may differ in terms of avatar features. As a result of the literature review, avatar design features were categorized. These categories are physical appearance, movement features, communication features, iconicity, graphical presentation level, the character being 2D or 3D, and the features of clothing and accessories. Evaluation form including these categories and their features and criteria was listed on Table 2.

Table 2. Evaluation form

Category	Feature	Feature Items
1.Physical appearance	Gender	Woman, Man, Other (robot & animal)
	Hair color	Colors
	Head	Large, Medium, Small
	Arm	Long, Normal, Short
	Palm	Large, Normal, Small
	Finger	Long, Normal, Short
	Eye shape	Large, Medium, Small
	Eye color	Colors
	Hair long	Long, Short, Empty
	Eyebrow	Yes, No
2. Movement features	-	
3. Communication features	-	
4. Iconicity	Level of iconicity	Realistic, Iconic
5. Graphical presentation	Level of quality	1 (*poor*) to 5 (*excellent*)
6. Dimension	Dimension	2D, 3D
7. Features of clothing and accessories	Clothing type	Different clothing types
	Accessories	Different accessory types

Since the many avatars' animation could not be reached, evaluations were made on the still images. For this reason, movement, and communication features didn't take into evaluation. Besides, some features in the physical appearance category, which are difficult to determine objectively from graphics were also not considered in the evaluation. In conclusion, all sign language avatars in the study are 3D. Therefore, the line style, line direction and line shape criteria of 2D avatars could not take into evaluation.

Feature of gender which is in the category of physical appearance is grouped as women, men and other (robot, animal). Eye and hair colors in the same category were categorized by color. Finger, palm and arm length, head and eye sizes and weight in the physical appearance category were evaluated on three levels (Large, Medium, Small / Long, Normal, Short). The eyebrow feature,

which is another physical feature, was examined whether the avatar had it or not. The level of iconicity was evaluated in the category of iconicity. For this, realistic and iconic values were used as the iconicity level. In the graphical presentation category, the features of shape, texture, color, lighting, surface, and shading, among the features of avatars, were evaluated over five point scale (very high[5], high[4], medium[3], low[2], very low[1]). In the Dimension category, the design method of avatars, whether 2D or 3D, was examined. As last, clothes and accessories were evaluated by making their own categories.

In order to determine sign language avatars, systematic literature review and examination of application stores were carried out by the researchers. This process is summarized in Figure 3. In the literature, there are many studies developed for sign language translation using avatars (Hansen et al., 2018; Liu et al., 2009; Ward et al., 2017; Yang et al., 2014; Yousaf et al., 2018). In addition, there are also accessible sign language avatars used in Google Play application platform and web environment. In this context, a search was made with the search query ("deaf" OR "hearing impaired" OR "hard of hearing" OR "hearing loss") AND ("avatar" OR "pedagogical agent" OR "virtual human"). As a result of the search query, forty-three studies having sign language avatars were found in 723 publications. When these forty-three articles were examined that the same avatar design was used in some of them. In this context, as a result of the literature review, 28 unique sign language avatars were found. In addition, based on the articles reviewed, a total of 18 avatars used in eSIGN (eSIGN, 2021), ViSiCAST (ViSiCAST, 2021) and Vcom (Vcom3D, 2019) projects were found. As a result of the search made on the Google Play application platform with the term "sign language", twenty avatars were found in 273 applications examined. Apart from this, thirteen more avatars used in sign language studies obtained through web searches were found. Some avatars have been found to take place more than once in both different studies and different applications. As a result, a total of seventy-nine unique sign language avatars were examined. The reviewed avatars can be found in the appendix section.

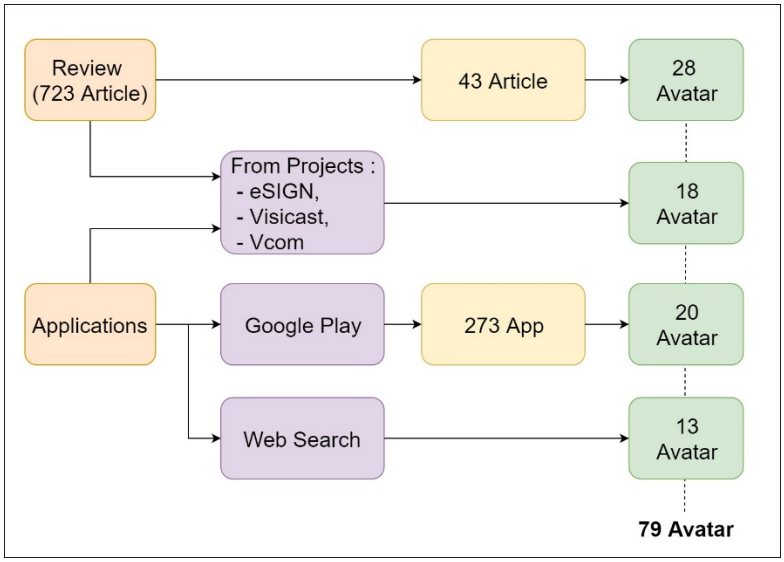


Figure 3. Search process of sign language avatars

Focus Group Discussions

Using the evaluation form (Table 2), seventy-nine sign language avatars were evaluated by researchers. This evaluation was carried out to determine the features of the avatars have in terms of design rather than their suitability for sign language For this reason, it is aimed that experts should be competent in terms of evaluating design rather than knowing sign language. In this context, the process was carried out in the form of focus group discussions. Focus group meetings are generally considered as interviews that consist of a small number of members and allow group discussion on a specific topic (Remler & Van Ryzin, 2021). In this research, with the focus group discussions, it is aimed to discuss the points that can be disputed on the visual appearance categories, to find common decisions and to evaluate all the criteria in detail. Evaluations were made within the framework of the avatar design features specified in Table 2. In this process, the designs of 79 sign language avatars were examined one by one by the researchers. Owing to the focus group discussions, it was aimed that all researchers make an evaluation with a consensus by minimizing individual errors. Focus group discussions were completed in three sessions in a total of 4 hours and 40 minutes using video conferencing on an online platform. Graphics of each sign language avatar were shared on the screen in the sessions, and instant evaluations were made by all participants until a common opinion was reached within the relevant categories.

Data Analysis

As a result of the focus group discussions, the number of repetitions of the avatar design features specified in Table 2 was evaluated. In this context, how many times each feature was repeated in 79 avatars examined. The obtained results were presented in the findings section in table form.

FINDINGS

The first noticeable detail in the visual features of the avatars is that the perspective typically displays the avatar from the waist up (Table 2). 79 out of the 73 (%92,4) avatars have this appearance. As a result of the evaluation of sign language avatar visual appearances, it is seen that 38 of 79 avatars are modeled as male (48.1%) and thirty-six as female (45.6%) in terms of gender.

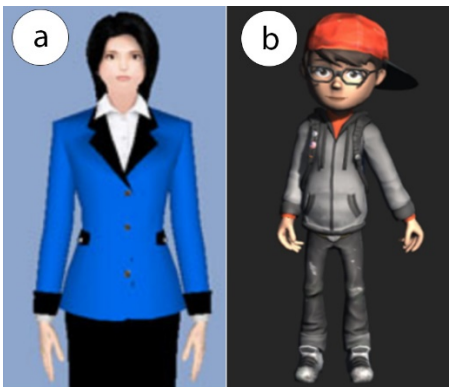


Figure 4. Realistic and Iconic Sign Language Avatar Examples (Realistic avatar on the left, iconic avatar on the right)

It is seen that five avatars (6.3%) are modeled in robot, rabbit, cat, fox, and panda form. 41 of 79 avatars' visual appearance are iconic (51.9%) and thirty-eight of them are realistic (48.1%). An example of realistic and iconic avatars is presented in Figure 4.

Table 3. Iconicity according to the source

Iconicity	Publications	Applications	Publication and Applications	Total
Realistic	17	18	3	38
Iconic	11	29	1	41
Total	28	47	4	79

While 28 of 79 avatars examined are found in scientific studies, forty-seven of them are found in mobile and web applications for sign language. Small amount of the avatars (n = 4) has been used both in the articles and in the applications. Table 3 summarizes the environments where avatars are presented as realistic or iconic. So, it is seen that while realistic avatars are preferred in publications, iconic avatars are preferred in applications.

Table 4. Iconicity and graphical presentation level

Graphical presentation level	Iconic (n)	Iconic (%)	Realistic (n)	Realistic (%)
Very High (5)	13	31,7	1	2,6
High (4)	12	29,3	7	18,4
Medium (3)	7	17,1	21	55,3
Low (2)	8	19,5	5	13,2
Very Low (1)	1	2,4	4	10,5
Total	41	100	38	100

Another finding about realistic and iconic avatars is that the graphical presentation levels of avatars are different. Table 4 shows the graphical presentation levels of iconic and realistic avatar visual appearance. It is seen that the visual graphical presentation of forty-one avatars designed as iconic is generally high (29.3 %) and very high (31.7%) graphical presentation (61%). On the other hand, it is seen that realistic avatars generally (55.3%) have a medium level (n = 21) graphical presentation level.

When Table 4 is examined, it is seen that while the number of realistic avatars designed with a very high level of graphical presentation is 1, the number of iconic avatars is 13. On the other hand, the number of realistic avatars designed with a very low level of graphical presentation is four, the number of iconic avatars with a very low graphical presentation level is only one. Examples of realistic and iconic designed avatars with very low (a, b) and very high (c, d) graphical presentation feature are shown in Figure 5.

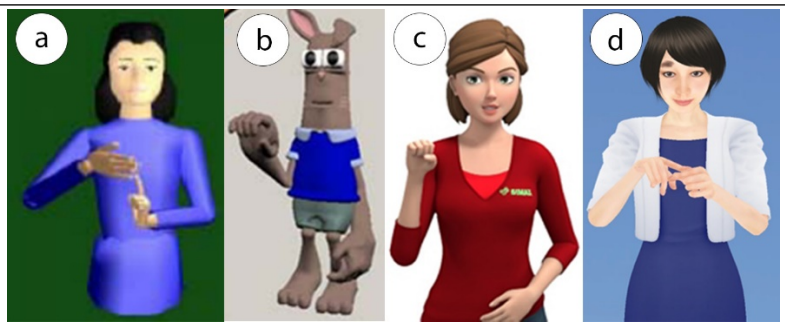


Figure 5. Realistic (a, d) and Iconic (b, c) Designed Avatars with Low (a, b) and High (c, d) Graphical Presentation

Another finding of the study is related to the lengths used in avatar designs. In this context, finger, palm, arm, head, and eye sizes were evaluated. In Table 5, frequencies of head and eye sizes are presented according to realistic and iconic avatars.

Table 5. Frequencies of avatars' head and eye sizes

Parts	Eye		Head	
Iconicity	Realistic	Iconic	Realistic	Iconic
Big (n)	1	35	1	31
Big (%)	2,6	85,4	2,6	75,6
Normal (n)	37	6	36	10
Normal (%)	97,4	14,6	94,7	24,4
Small (n)	0	0	1	0
Small (%)	0	0	2,6	0
Total	**38**	**41**	**38**	**41**

When Table 5 is examined, it is seen that eyes in realistic avatar are generally designed in normal sizes (n = 37, 97.4%). However, in iconic designs, it is seen that eyes are designed larger than normal (n = 35, 85.4%). When head size is examined, it is seen that realistic avatars are generally designed in normal (n = 36, 94.7%) sizes, whereas iconic avatars are designed in large size (n = 31, 75.6%). Another noticeable finding is that the eye or head measurements are not designed in small sizes except for only one avatar.

Table 6. Frequencies of finger, palm, and arm lengths

Parts	Finger		Palm		Arm	
Iconicity	Realistic	Iconic	Realistic	Iconic	Realistic	Iconic
Big (n)	1	15	1	9	1	6
Big (%)	2,6	36,6	2,6	22	2,6	14,6
Normal (n)	37	20	36	27	37	32
Normal (%)	97,4	48,8	94,7	65,9	97,4	78
Small (n)	0	6	1	5	0	3
Small (%)	0	14,6	2,6	12,2	0	7,3
Total	**38**	**41**	**38**	**41**	**38**	**41**

Table 6 shows frequencies related to finger, palm, and arm lengths in avatar visual appearance. In the evaluations of finger length, it is seen that realistic avatars have normal sized designs (n = 37, 97.4%). However, finger lengths are generally designed as normal (n = 20, 48.8%) or large (n = 15, 36.6%) sizes in iconic avatars. As for the evaluations of the palm, it is seen that realistic avatars have normal sized designs (n = 36, 94.7%). However, it was determined that palm lengths were generally designed as normal (n = 27, 65.9%) or large (n = 15, 36.6%) in iconic avatars. Considering the arm lengths, it is seen that the arm lengths of normal sizes are generally used in both realistic and iconic avatar designs.

In Table 7, head-eye, hand-finger-arm lengths were evaluated in terms of gender. Accordingly, it is seen that the head and eye sizes are designed as normal or larger than normal in male and female avatars. On the other hand, arm, finger, and palm sizes are mostly designed in normal sizes.

Table 7. Eye, head, arm, finger and palm sizes and lengths according to gender

Gender	Parts	Big		Normal		Small	
		n	%	n	%	n	%
Male	Eye	17	44,7	21	55,3	0	0
	Head	17	44,7	20	52,6	1	2,6

		Long		Normal		Short	
		n	%	n	%	n	%
	Arm	4	10,5	31	81,6	3	7,9
	Finger	9	23,7	26	68,4	3	7,9
	Palm	6	15,8	29	76,3	3	7,9
		Big		Normal		Small	
		n	%	n	%	n	%
	Eye	14	38,9	22	61,1	0	0
	Head	10	27,8	26	72,2	0	0
Female		Long		Normal		Short	
		n	%	n	%	n	%
	Arm	2	5,6	34	94,4	0	0
	Finger	5	13,9	31	86,1	0	0
	Palm	3	8,3	33	91,7	0	0

When the eye colors used in avatars are examined, the most preferred two eye colors are black (n=27) and brown (n=25). As the third color, blue (n=16) is used in avatar visual appearance. Green (n=9), white (n=1) colors are also used. In addition, the eye color of two avatars could not be determined. Hair colors used in avatars were also evaluated. Similarly, to eye color, black (n=32) and brown (n=27) is mostly preferred color in avatars' hair designs. Yellow (n=7), red (2), blue (n=2), orange (n=1), and green (n=1) colors are also used for hair designs. On the other hand, hair color could not be determined in 7 avatars.

When the avatars are examined in terms of costume design, it is seen that they are often designed with trousers (n=42), t-shirts (n=35), shirts (n=15) and skirts (n=10). When the type of costume was examined according to gender, male avatar designs usually use trousers (n=25), t-shirt (n=22), and shirt (n=5). Other types of costumes used in male avatars are blouse (n=1), vest (n=3), suit (n=3), sweater (n=2), shorts (n=2), singlet (n=1), jacket (n=2), dress (n=1), costume (n=1), coat (n=1), and astronaut costume (n=1). On the other hand, female avatar designs usually use trousers (n=17), t-shirts (n=13), skirts (n=10), shirts (n=10) and blouses (n=6). Other types of costumes used in female avatars are blouse (n=6), vest (n=1), sweater (n=4), jacket (n=4), and dress (n=4). Common types of costumes are presented in Table 8.

Table 8. Types of costumes common in avatars

Type of costume	Male		Woman	
	n	%	n	%
Trousers	25	36	17	25
T-Shirt	22	32	13	19
Shirt	5	7	10	14
Skirt	0	0	10	14
Blouse	1	1	6	9
Other	17	24	13	19
Total	**70**	100	**69**	100

When the accessories and clothing details of avatars are examined, it is obvious that some designs do not contain accessories (nmale = 11, nfemale=18). However, some designs include one or two accessories. It was observed that the number of accessories used in male avatars (n=38) was higher than the number of accessories used in female avatar (n=19) visual appearance. While eight types of accessories are used in female avatars, nineteen types of accessories are used in male avatars. Other types of accessories used in female avatars are belt (n=5), logo (n=4), necklace (n=3), pattern (n=3), necktie (n=1), glove (n=1), earring (n=1), and badge (n=1). Similarly, accessories used in male avatars are: Belt (n=13), Tie (n=5), Glasses (n=3), Logo (n=2), Turban (n=2), Glove (n=1), bag (n=1), pattern (n=1), button pattern (n=1), handkerchief (n=1), bow tie(n=1), cape (n=1), colorful clothes (n=1), hat (n=1), crown (n=1), collar (n=1), name badge(n=1), and vest (n=1). The most used accessory in avatars is the belt (n=18). The distribution of accessories is presented in Table 9.

Table 9. Accessory used in avatars

Accessory	Male		Female	
	n	%	n	%
Belt	13	34	5	26
Tie	5	13	0	0
Glasses	3	8	0	0
Pattern	0	0	3	16
Necklace	0	0	3	16

Logo	2	5	4	21
Other	15	40	4	21
Total	38	100	19	100

While avatars mostly did not use cultural clothing (n = 76), only three avatars had cultural visual appearance. The most used accessory for both male and female avatars was the belt.

DISCUSSION

In studies on avatar designs, it is seen that the gender of the avatar is a significant factor. In the study of Plant et al. (2009) conducted with middle school students, it was determined that female avatars were more effective than male avatars. In addition, Baylor (2011) stated that the most effective social avatar model is a young, calm, and female avatar. While realistic human-like avatars increase social interaction, female avatars are more preferred than male avatars (R. F. Khan & Sutcliffe, 2014) . Although it is stated in the literature that female avatars are more effective, the number of male and female designs used in the examined avatars is close to each other.

Sign language avatars are often seen above the knee (n=73, %92,4). This may be due to the creation of sign languages around the upper part of the body and the head region. Similarly, in the study conducted by Pfau and Quer (2010), it was stated that facial expressions, head and body movements, and mouth movements are used in addition to hand signs in sign languages. It is known that eyebrow movements (eyebrow lowering, eyebrow lifting), directional gaze, speaking, lip movements, head movements and body tilting movements are widely used in sign languages (Zeshan, 2004).

Although eye (55%) and head (53%) are usually designed in normal sizes, there are also avatars with big eye (45%) and big head (45%) sizes, which cannot be underestimated. When avatars are evaluated in terms of iconic or realistic visual appearance, it is seen that the head and eyes are designed bigger than normal in most of the iconic characters. The big head and big eye designs used in iconic characters are a common feature in sign language avatars as well. Mehta, Pai, and Singh (2020) emphasize that children's avatar preferences are in the form of an iconic character with big eyes. Similarly, it is stated that designs with a thin body and big head add cuteness to the character (Bancroft, 2006). In addition to this, it is recommended that the hand and head sizes should be bigger than normal in order to understand the signs and non-manual signs more clearly (Lopes, 2016).

Finger, palm, and arm lengths are designed normally in iconic and realistic avatars. However, long-fingered designs are often found in iconic avatars. In this context, it would be beneficial for realistic avatars to choose hand and arm lengths close to human dimensions. On the other hand, for iconic avatars, it would be useful to choose normal or long finger lengths according to the target group. However, finger, palm, and arm lengths should not be designed in small sizes. This type of design stands out as a feature that should be considered in terms of understanding finger signs. Sign language is a communication method limited by the eyesight (Siple, 1978). For this reason, speed and spatial resolution are important for the sign language to be fully recognized on digital screens (Muir, 2005). In this context, the dimensions of the elements (finger, hand, arm, eye, and head) that perform the sign are expected to be in traceable dimensions.

The number of iconic and realistic avatars are close to each other in the studies examined. While iconic avatars are generally used in applications (n = 29, 62%), realistic avatars are generally used in publications (n = 17, 61%). Kipp et al. (2011) stated in their study on individuals with hearing impairment between the ages of 20-50 that iconic avatars (cartoon animation) are mostly preferred. However, in the same study, it is emphasized that it would be more appropriate to use realistic avatars in adult groups and iconic avatars in younger groups. In another study, McCloud (1993) states that the increase in the iconicity of the avatar, the more people will adopt the avatar. In other words, a realistic avatar will be adopted by more limited sample group due to its lower representation level. In addition, thanks to the preference of iconicity in avatars, it supports more effective designs by staying away from the effect of the uncanny valley (Mori et al., 2012). Adamo-Villani and Anasingaraju (2016) also state that iconic characters look more attractive than realistic characters. When we evaluate the level of iconicity in these terms, it is seen that iconic avatars have an important effect in product-oriented sign language avatar studies. However, it seems that iconic avatars should be evaluated according to the environment where they will be used.

It requires time and effort to design a realistic avatar with high quality. But designing processes become easier with the developing 3D technologies (Min, 2004). On the other hand, according to the uncanny valley (Mori et al., 2012) theory, realistic avatars are expected to be designed with high quality and almost flawlessly. Otherwise, if an avatar with realistic features is not designed with high quality, it will have negative effects on users. The high level of graphical presentation of realistic avatars can cause difficulties in terms of modelling and the infrastructure. Especially, increasing the resolution, texture and shadow detail can cause various problems in rendering times and graphic infrastructures. At this point, high graphical presentation levels are more applicable to iconic avatars. Jen and Adamo-Villani (2015) determined in their study that non-photorealistic signs presented in finger alphabet teaching, increase readability more than realistic signs. Furthermore, Adamo-Villani and Anasingaraju (2016) state that although there is no difference between realistic and iconic visual appearances in the recognition of signs, iconic characters have a significant effect on the attractiveness of the avatar.

Avatar clothing and colors should also be taken into consideration to see the sign more clearly. When the clothes and accessories are examined, it is seen that 32% of the avatars have a plain clothing without details. It was determined that the most preferred clothing types in avatars are trousers, t-shirts, shirts, and skirts. Considering that sign language interpreters also try to

increase contrast and sharpness by wearing plain and dark colors (Siple, 1978), plain clothing is important in transferring sign language. On the contrary, it is seen that some avatars are designed with detailed and colorful elements. It is thought that these avatars can be preferred to attract the attention of young individuals.

CONCLUSION AND RECOMMENDATIONS

Sign language avatars differ from avatars used in games or educational materials. It is important to transfer the movements appropriately to maintain communication in sign language. However, educational agents used in games or educational materials can directly use channels such as text and voice to communicate with individuals. At this point, when designing sign language avatars, body parts including sign language movements should be designed more carefully and functionally compared to agents in game or educational settings. For this reason, one of the important findings that we come across is that most of the sign language movements are performed in the upper part of the body. Therefore, avatars for sign language should be designed in a way that the upper part of the body is visible. Contrary to the scientific research that female characters are more effective in avatar designs, there is no difference in terms of gender distribution in avatars examined for sign language. On the other hand, it is necessary to consider the target group in the selection of iconic or realistic visual appearances. Iconic or realistic avatar visual appearance have distinctive features. Eye, head, arm, and fingers should be larger than normal to develop an iconic design. Eye, head, finger, palm, and arms should be in normal sizes to develop a realistic design. Finally, the visual channel is significant in the formation of information for deaf individuals. For this reason, it is important to convey information directly to the visual channel when communicating with deaf individuals. Therefore, in order to avoid overloading the visual channel, choosing simple designs in the use of clothing and accessories in avatars will be beneficial for an effective communication process.

Declaration of Conflicting Interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.

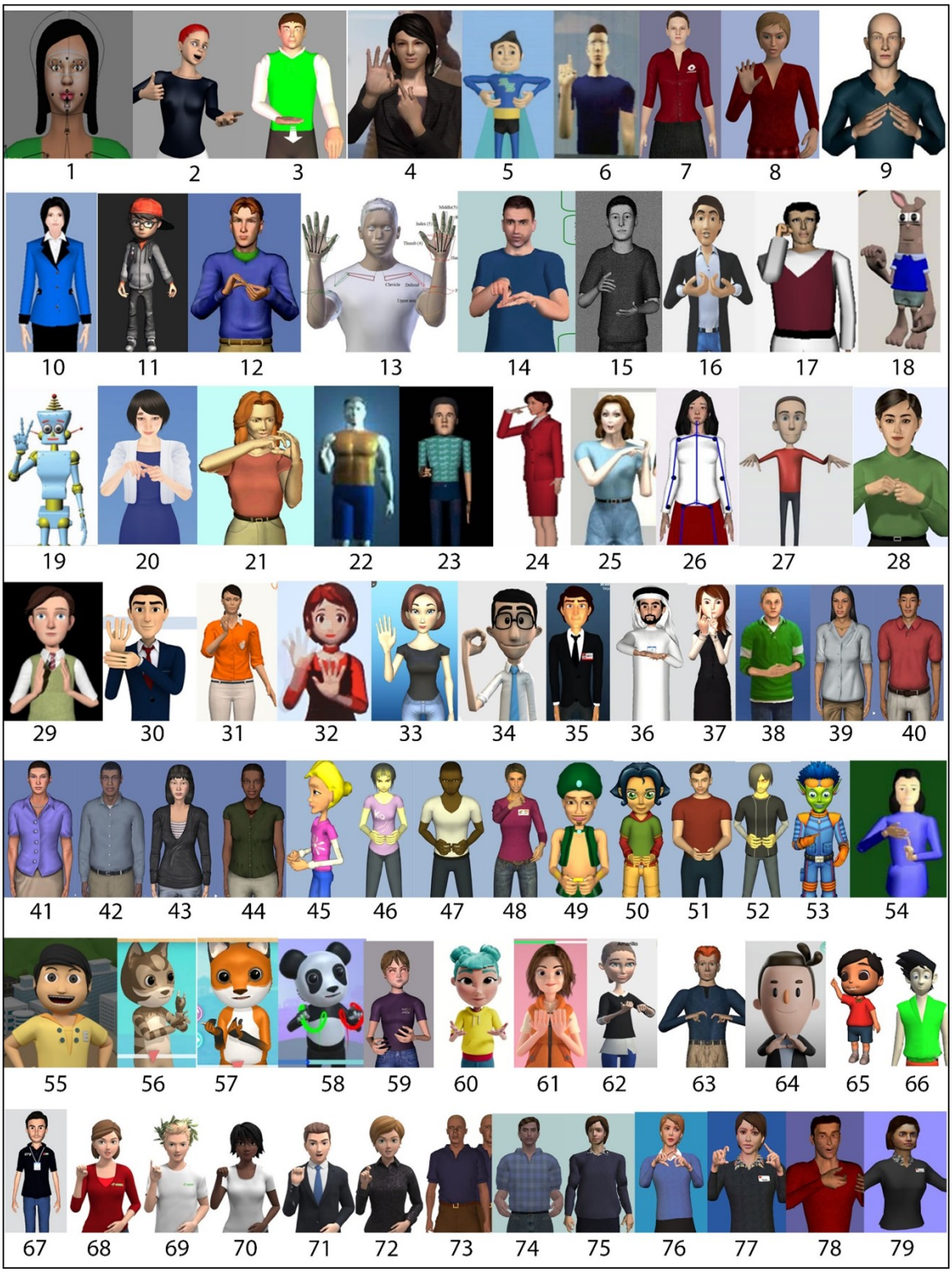
Funding

This work was supported by Scientific Research Projects Unit of Karadeniz Technical University (Grant number: SÖA-2018-7733).

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

APPENDIX



1: (de Araújo et al., 2013; Silva et al., 2012), **2**: (V. López-Ludeña et al., 2014; Verónica López-Ludeña et al., 2013), **3**: (López-Colino & Colás, 2012), **4**: (J. Oh et al., 2014), **5**: (Adamo-Villani et al., 2013), **6**: (Al-Khalifa, 2011), **7**: (De Martino et al., 2017), **8**: (Ebling & Glauert, 2016; JASigning, 2012), **9**: (Bouzid et al., 2016, 2015; Bouzid & Jemni, 2014, 2017), **10**: (Li et al., 2014; Wang et al., 2010), **11**: (Mehta et al., 2020), **12**: (Hansen et al., 2018; Vcom3D, 2008), **13**: (Punchimudiyanse & Meegama, 2017), **14**: (Elliott et al., 2008; Kennaway et al., 2007; San-Segundo et al., 2012), **15**: (Vesel & Robillard, 2013), **16**: (Yousaf et al., 2018), **17**: (Bouzid & Jemni, 2013a, 2013b; Ghoul & Jemni, 2009), **18**: (Adamo-Villani et al., 2004), **19**: (Adamo-Villani & Wilbur, 2010), **20**: (Balayn et al., 2018), **21**: (Braffort et al., 2016; Braffort & Dalle, 2008), **22**: (Brega et al., 2014), **23**: (Papadogiorgaki et al., 2005), **24**: (Liu et al., 2009), **25**: (Segouat & Braffort, 2009), **26**: (Y. J. Oh et al., 2007), **27**: (Ward et al., 2017), **28**: (McDonald et al., 2016), **29**: (Naert et al., 2020), **30**: (Engelsiz Çeviri, 2018), **31**: (Turkcell İletişim Hizmetleri, 2020), **32**: (MDI.inc, 2016), **33**: (Posibillian Tech, 2020), **34**: (Hand Talk, 2013), **35**: (ProDeaf, 2013), **36-37**: (Mind Rockets, 2019), **38-39-40-41-42-43-44**: (Vcom3D, 2008), **45-46-47-48-49-50-52-53**:

(JASigning, 2012), **51**: (JASigning, 2012; Patel et al., 2020), **54**: (Yang et al., 2014), **55**: (BAXS Technology, 2017), **56-57-58**: (MocapLab, 2018), **59**: (Signlab Nuevas Tecnologías, 2012), **60**: (StorySign, 2020), **61**: (Leepi, 2020), **62**: (Sign Accessible Technologies, 2019), **63**: (Reem Ibrahim, 2017), **64**: (Hear Me ID, 2021), **65**: (IMI Creative Sdn Bhd, 2020), **66**: (Team Crazy Developers, 2019), **67**: (Mind Rockets Inc, 2019), **68-69-70-71-72**: (Sign Time, 2021), **73-74-75-76-77-78-79**: (eSIGN, 2021)

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