Aphasiology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/paph20

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To cite this article: Claire Reymond, Sandra Widmer Beierlein, Christine Müller, Ricarda Reutimann, Katrin P. Kuntner, Noelia Falcon Garcia, Indre Grumbinaite, Simone Hemm Ode, Markus Degen, Fabrizio Parrillo, Stefan Karlin, Sunghea Park, Michael Renner & Anja Blechschmidt (2022): Naming Images in Aphasia: Effects of Graphic Representations and Photographs on Naming Performance in Persons With and Without Aphasia, Aphasiology, DOI: 10.1080/02687038.2022.2064421

To link to this article: https://doi.org/10.1080/02687038.2022.2064421

Published online: 03 May 2022.

APHASIOLOGY
https://doi.org/10.1080/02687038.2022.2064421

Naming Images in Aphasia: Effects of Graphic Representations and Photographs on Naming Performance in Persons With and Without Aphasia

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ABSTRACT

Background: Picture naming is a common tool in aphasia diagnosis and therapy. However, opinions differ as to which type of image (e.g., photographs, drawings) is most suitable for naming tasks and whether there is a difference on naming correctness and latencies based on image type. Moreover, recent studies have mainly analysed colour photographs and black-and-white line drawings leaving out image types like graphic representations that apply image features that can facilitate naming such as colour, controlled size, or texture.

Aims: To shed more light on appropriate image types for persons with aphasia, we created graphic representations depicting nouns and verbs and compared them to photographic stimuli in a naming task including persons with aphasia (PWA) and a control group (CG).

Methods & Procedures: 33 PWA and 33 age matched persons (CG) participated in the study. Naming correctness and latencies were measured in two different conditions: concepts depicted as coloured photographs vs. as graphic representations. 128 pictures of linguistically controlled German-language concepts (64 nouns, 64 verbs) had to be named. The designed graphic stimuli were developed by professional designers based on photographs. The photographs were selected from stock image databases according to a defined image concept. This image concept was based on empirical findings regarding image features that facilitate naming (e.g., colour, texture, shading) and was applied to the selection of the photographs as well as to the creation of the graphic representations. The images were presented in pseudo-randomized sequences on a tablet and all reactions of the participants were videotaped. The data from the main study was analysed using generalized linear mixed models (GLMM) and linear mixed models (LMM).

Keywords
aphasia; picture naming; image type; image features; E-Inclusion

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Outcomes & Results: Our analysis showed no significant difference in naming correctness and latencies between photographic and graphic stimuli. On average, PWA named terms presented as graphical representations more correctly than the photographs. But this difference was below the significance level.
Conclusions: In our study we showed that graphic representations, when including image features that facilitate naming like colour, texture, and shading, can evoke the same naming performance as photographs. Graphic representations can thus be used in combination with photographs in an image set, especially when depicting concepts that benefit from reduced representation, e.g., verbs. We therefore advocate the transparent and methodologically stringent implementation of image features that facilitate naming when creating image stimuli.

Introduction

Naming images is a common paradigm for investigating unimpaired (Bates et al., 2003; Glaser, 1992; Kohnert, 2004) and impaired language processing (e.g., Cotelli et al., 2007; Cuetos et al., 2005; Howard et al., 1985; Kohn & Goodglass, 1985; Laine et al., 1997). Naming objects or scenes depicted on pictures is also used to diagnose the severeness of aphasia using standardized and psychometrically validated language tests (e.g., Aachener Aphasie Test; Huber et al., 1983; Boston Naming Test; Kaplan et al., 2001; Bielefelder Aphasie Screening; Richter et al., 2006; Quick Aphasia Battery; Wilson et al., 2018) or to train and re-learn language in aphasia therapy (e.g., Brumbi et al., 2017; Pfab et al., 2015; Stark, 1992). Despite the longstanding use of images in aphasia diagnostics and therapy, there is still disagreement on what relevant images for persons with aphasia should actually look like (Brown & Thiessen, 2018).

In this paper, the term *image type* refers to the technique used to create an image and categorizes an image as, for example, drawing, photograph, or painting. Each image type can be further differentiated: For example, drawings can vary in terms of their level of generalization (from as detailed as possible like in scientific illustrations to simplified as in pictograms). Different image types in the context of aphasia—usually classified as *drawn* or *photographic* stimuli—have been investigated regarding their effect on naming performance. *Drawings* mostly refer to a heterogeneous group of black-and-white or coloured line drawings. In line drawings the depicted figure is outlined with a black line and presented on a white background, in coloured line drawings the surfaces are coloured. *Pictograms, pictographs* or *icons* are often described as a sub-category of drawn stimuli and are mostly used interchangeably for the same image type: a black graphic form that conveys meaning through its pictorial resemblance to a physical object. *Photographs* are coloured or black-and-white photographic images, showing objects or persons embedded in a scene or cropped and shown on a plain background.

Comparing object recognition in colour photographs and black-and-white line drawings in healthy participants, Heuer (2016) showed that object recognition was facilitated by colour photographs. Based on this, she argued that the image types used in aphasia diagnostics should be examined in more detail. But while some older studies have demonstrated differences of image type on naming performance (Benton et al., 1972;

Bisiach, 1966), others have shown no such effects (Corlew & Nation, 1975). The current heterogeneity of available picture stimuli and their potential effects on naming performance places a unique challenge for practitioners in aphasia therapy when it comes to providing appropriate image material to their patients. The vast variety of pictures to choose from might also cause uncertainty as to which types of images should be used in aphasia diagnostics (Brown & Thiessen, 2018). The aim of our paper is therefore to clarify the role of image type on naming performance in persons with aphasia (PWA) and adults without aphasia (control group: CG). We do so by comparing naming responses (naming correctness and naming latencies) to two image types, which we created or selected from professional image databases.

Effects of image type on naming performance and communication behaviour in PWA

Drawn stimuli may be regarded as a translation of objects, persons or scenes seen in the real world. As such, drawings offer the possibility to focus on core features of an object or scene, accentuating the meaning of the image and leaving out unnecessary details. Specifically line drawings are said to facilitate text comprehension in normal (Readence & Moore, 1981) and impaired readers (Doak et al., 1996; Mayer & Villaire, 2007) because keeping the picture simple in construction seems to be better suited to enhance comprehension than artistic or overly detailed images (Readence & Moore, 1981, p. 222). Line drawings are also considered beneficial for evoking language in PWA (Kagan & LeBlanc, 2002; Pound et al., 1999) and are therefore traditionally used in diagnostic tests (e.g., Huber et al., 1983; Richter et al., 2006). When studying objects depicted as coloured line drawings, black-and-white line drawings, and black-and-white line drawings with lines drawn across the picture, Bisiach (1966) compared recognition and naming accuracy in nine PWA. There was no significant difference in recognition of the images. However, the ratio of correct naming based on the correctly recognized images was significantly higher for the coloured line drawings than for the black-and-white and the crossed-out images. Benton et al. (1972) compared small and large black-and-white line drawings of objects and real objects on naming accuracy in 18 PWA. A significant difference in naming accuracy between line drawings and objects was observed—although the naming performance in the different conditions were extremely close to each other. The authors suggest that real objects may provide more opportunity for association and semantic activation than line drawings which may in turn favour retrieval of the object' name. The size of line drawings did not influence naming accuracy. Bisiach (1966) and Benton et al. (1972) showed that proximity to the real object (as a detailed colour drawing or as a real object) has a positive influence on naming performance. In contrast to those results, Corlew and Nation (1975) found no differences based on different stimulus types. They investigated the correct naming of real objects compared to reduced black and white line drawings of the same objects. The naming responses of 14 PWA did not differ significantly based on the stimuli.

Photographs depict objects, scenes, or persons similarly to how they are perceived in everyday life. In this sense, photographs show what is depicted with all its rich details which facilitates object recognition and may therefore be beneficial for language processing in PWA (Heuer, 2016). When comparing the effect of coloured and black-and-white photographs of objects on naming latency and correctness, Mohr (2010) showed that 29 PWA as well as 60 adults without aphasia named the objects on the colour photographs significantly faster and more accurately than the black-and-white photographs.

The effectiveness of photographs to support communication in PWA has been shown in studies comparing photographs with line drawings and/or pictograms. Analysing communication behaviour with the support of photographed objects and coloured pictograms of objects, Ho et al. (2005) described that their two participants with global aphasia communicated about more topics and had fewer communication interruptions when supported by both image types than when no images were present. Additionally, more pointing behaviour was observed with photographs than with pictograms. When testing the use of augmented and alternative communication devices, Griffith et al. (2014) showed that four PWA more frequently used personally relevant photographs than coloured line drawings when retelling a narrative. However, participants orally reported both image types to be equally helpful. Ma et al. (2009) investigated different types of images (coloured and black-and-white photographs, black-and-white pictograms) to icons in 50 PWA on their effectiveness in communication replacement. In this study, icons denote pixelated black-and-white line drawings with and without colour. Icons and images were shown to be equally functional in conveying information and thus equally suitable for communicating single words (Ma et al., 2009).

Effects of image features on naming performance for objects

In order to correctly name an object depicted in a picture, it must first be correctly recognised (Alario et al., 2004; Heuer, 2016; Humphreys et al., 1999). At the same time a variety of image features influence recognition and naming performance in persons without neurological deficits (for an overview see Johnson et al., 1996). Image features describe formal characteristics of an image such as the colour used or the contrast within an image. The size of the depicted object affects the time needed to name an object: Depicted objects that are smaller than 4° to 6° of visual angle may be difficult to perceive because they are too small. Very large images, in turn, require eye movement for optimal foveal perception, increasing the difficulty of identification (Biederman & Cooper, 1992; Johnson et al., 1996, p. 117). Maintaining a realistic size ratio within an object category was considered in the image set of Snodgrass and Vanderwart (1980). The objects' colour is relevant when it underlines the prototypicality of the object. When colour-prototypical objects are presented in incongruent colours, they are named slower than when shown in their prototypical colour (Naor-Raz et al., 2003; Rossion & Pourtois, 2001; Therriault et al., 2009; Wurm et al., 1993). A medium colour contrast of the object has been shown to provoke faster naming latencies than low colour contrast (Brodie et al., 1991, Experiment 1). The depicted texture of an object (depiction of the materiality of the object) and shading (dark and light coloured surfaces on an object simulating three-dimensionality) facilitates naming performance (Adlington, 2009; Brodie et al., 1991; Rossion & Pourtois, 2001). The view on objects also plays a role in naming performance: When objects are displayed in the canonical view, that is, in the position where the information identifying the object is optimally visible (e.g., seeing a zebra from the side favors recognition compared to when it is seen from above), naming of the object is fastest (Cutzu, 1994; Palmer, 1981; Snodgrass & Vanderwart, 1980).

Depictions of verbs

It is known that naming verbs is more demanding than naming objects, for persons without neurological deficits as well as for PWA (Bastiaanse et al., 2003; Bastiaanse & Jonkers, 1998; De Bleser & Kauschke, 2003; Mätzig et al., 2009; Kim & Thompson, 2000). This is based on factors like differences in semantic representation (Vinson & Vigliocco, 2002) or the higher morphological complexity of verbs (Vigliocco et al., 2006). In addition, the imageability of verbs poses a challenge compared to the imageability of nouns (Bird et al., 2003) whereas "imageability" is defined as the "extent to which an object name evokes few or many different images for a particular object" (Alario et al., 2004, p. 141). Bird et al. (2003) investigated the effect of imageability in four PWA and showed that if the depicted verbs were controlled for imageability no differences in naming, reading or writing were found for verbs and nouns. This suggests that the PWA found verbs to be more difficult because of the difficulty of representation, rather than the word class. Where depicting concrete nouns allows for a clear boundary of the figure on a plain background, verbs are characterized by the need to show actors in a more or less complex context. This fundamental difficulty is reflected in the comparably small number of image sets that depict verbs (for image sets containing depictions of verbs, see Fiez & Tranel, 1997; Khwaileh et al., 2018; Masterson & Druks, 1998; Székely et al., 2004). The set of 280 images by Fiez and Tranel (1997) shows verbs as grayscale photographs of "persons, animals, and objects engaged in ongoing actions" (p. 547) on a plain or structured background. Khwaileh et al. (2018), Masterson and Druks (1998) and Székely et al. (2004) provided sets of depicted verbs by assembling black-and-white line drawings of persons, animals or objects performing different actions. Akinina et al. (2015) have provided a set of 375 black-and-white as well as a coloured version of line drawings depicting action pictures and verbs. Investigating the depiction of verbs, Thiessen et al. (2016) have shown that task-engaged depiction (the depicted person turns towards the performed activity) draws significantly more visual attention of PWA as well as adults without aphasia to the objects than when the depicted person looks into the camera. This in turn might have a positive influence on the naming of activities.

In summary, the few studies exerted on the effect of different image types on naming performance when naming objects have produced mixed results. Some studies have indicated that if photographs were compared to reduced black-and-white line drawings, they evoked better naming performance. However, there is evidence that specific image features like controlled size, colour, texture and viewpoint on the object affect naming performance of objects in persons without neurological deficits (Biederman & Cooper, 1992; Johnson et al., 1996; Naor-Raz et al., 2003; Palmer, 1981; Therriault et al., 2009). Thus, comparing colour photographs with black-and-white drawings might restrict the positive effect of these features—all of which can be applied to drawings—on naming performance in PWA. To our knowledge, those image features have hardly been systematically implemented into image material depicting objects and verbs specially produced for PWA. The general need for image stimuli that are developed and controlled for relevant image features has also been recently addressed by Souza, Garrido, and Carmo (2020). Moreover, the comparably small number of image sets providing depictions of verbs have mainly used grayscale photographs, black-and-white or coloured line drawings. The predominant use of line drawings for depicting verbs in the existing image sets might suggest that a schematic and reduced image type may be beneficial for representing verbs.

Studies that have actually investigated the role of image types on naming performance in PWA and not merely in persons without aphasia is still quite small. To our knowledge, the effect of drawn stimuli that go beyond reduced (black-and-white) line drawings and implement image features that facilitate naming like colour, texture, and shading on naming correctness and latencies in PWA has hardly been researched so far and is the aim of our study[1]

Research Questions of the Present Study

In our study, we developed drawn stimuli incorporating image features that have been shown to have a favourable effect on naming performance, e.g. controlled size, colour, perspective, and texture (Adlington, 2009; Biederman & Cooper, 1992; Palmer, 1981; Rossion & Pourtois, 2001; Wurm et al., 1993). The type of stimuli we compared to colour photographs in our study were drawn on the computer using Adobe Illustrator and Adobe Photoshop (https://www.adobe.com). As such we consider our digital drawings to be a sub-category of the image type of drawings and refer to them as *graphic representations*. We compared naming correctness and naming latencies between these graphic representations and photographs depicting nouns and verbs in a picture naming task in a group of 33 PWA and an age-matched control group of 33 participants (CG).

This study was designed to assess whether photographic and graphic images affect naming correctness and naming latency of nouns and verbs for PWA. We also compared naming performance in PWA and the CG.

Materials and Methods

The study was approved by the Ethics Committees of Northwestern and Central Switzerland (EKNZ) and the Cantonal Ethics Committee Zurich (kek.zh.ch), Project ID: 2019-00084. The study was also registered at ClinicalTrials.gov, Identifier: NCT05164380.

Participants

A total of 33 adults with aphasia (*M*age = 58.1, *SD* = 13.6; 18 males, 15 females) were included in our study. The approximate number of participants was previously defined by a power analysis based on simulation. PWA were recruited in cooperation with local language therapists, hospitals, and rehabilitation clinics. PWA had to be diagnosed with minimal, mild, or moderate aphasia by the Aachener Aphasie Test (AAT; Huber et al., 1983). All of them were in the post-acute or chronic phase with a minimum of six weeks post onset. Twenty PWA were diagnosed with anomic aphasia, five PWA with Wernicke aphasia, seven with Broca aphasia and one participant with global aphasia. In 26 persons the aphasia was caused by an ischemic and

[1]For in depth information on the interdisciplinary project *E-Inclusion* in which this study was embedded see Widmer Beierlein et al. (2021)..

in three by a haemorrhagic stroke, two had a tumour and two a craniocerebral trauma. All participants had to show sufficient language comprehension to follow the instructions during the experiment and an attention span of minimum 45 minutes. Mild dysarthria or apraxia of speech was allowed but severe and moderate dysarthria as well as severe or moderate apraxia of speech were excluded based on an existing diagnosis and/or clinical impression of the language therapist. In addition, only participants were included in the study who achieved at least 3 points on the AAT-Scale for spontaneous speech (Huber et al., 1983) i.e., mild dysarthria/dysprosody. In order to participate in the study, the patient had to be medically diagnosed with no dementia and the language therapist had to have no suspicion of dementia. This was confirmed by the language therapist in a questionnaire. Further, participants had to have intact colour vision, normal or corrected to normal vision and hearing attested on a questionnaire filled out by the participant before study enrolment.

A total of 52 PWA were tested in our study. Of these, 19 had to be excluded for the following reasons: Ten persons no longer demonstrated signs of aphasia according to the AAT (Huber et al., 1983) at the time of testing. For two other persons, dementia was suspected. For another person, the AAT testing was older than two weeks, and one person displayed a moderate apraxia of speech and insufficient hearing. Five persons failed the screening-tests (see below): semantic access was insufficient for two PWA (controlled with the Pyramids and Palm Tree Test; Howard & Patterson, 1992), colour vision was deficient in two PWA (controlled with the Coloring of Pictures Test; De Renzi et al., 1972), and one PWA showed deficits in semantic access as well as in colour vision. Thus, all the 33 included participants fulfilled the inclusion criteria. Refer to Table 1 for description of all PWA.

The age-matched control group consisted of 33 participants (*M*age = 58.2, *SD* = 14.2; 16 males, 17 females) all with intact colour vision, normal or corrected to normal vision and hearing and no neurological diseases in their health history. They were recruited via inquiries sent to retiree associations, the researchers' circle of acquaintances as well as by asking relatives of participants with aphasia. A two-sided t-test for related samples (due to matching) showed no significant difference regarding age between individuals with and without aphasia (t (32) = 0.020, p = .984). Additionally, we investigated the difference in years of education: A Wilcoxon test (due to the non-normally distributed years of education) showed that the CG participants had significantly more years of education than the PWA (v = 97, p = 0.00183).

Stimuli

We created graphic representations of 128 words—64 verbs and 64 nouns to be compared to 128 photographs in our study. Eight trial items (four nouns, four verbs) were added to be used as examples before the main test items. The set of graphic representations can be seen and downloaded on the following platform: https://mediathek.hgk.fhnw.ch/einclusion/. The images may be used without the intention of financial gain and by citing the present article as a reference (See Fig. 1 as an example for the style of graphic representation).

Table 1 :Description of PWA

ID	Age	Gender	Handedness	Education [years]	First language	Aphasia type	Aphasia phase	Time since onset [months]	AAT Severity	AAT Severity naming	Aetiology	Lateralisation of damage
1	74	F	Right	10	Swiss German	Anomic	Post-acute	9	Light	Light	Ischemic stroke	Left
2	48	F	Right	12	Swiss German	Anomic	Chronic	40	Light	Light	Ischemic stroke	Left
3	53	F	Right	12	Swiss German	Anomic	Post-acute	10	Minimal	Light	Brain tumour	Left
4	60	M	Right	13	Swiss German	Anomic	Post-acute	6	Light	Light	Ischemic stroke	Left & right
5	72	M	Right	16	Swiss German	Anomic	Post-acute	7	Light	Minimal	Ischemic stroke	Left
6	62	F	Left (right for writing)	12	Swiss German	Wernicke	Chronic	16	Minimal	Medium	Ischemic stroke	Left
7	43	M	Right	13	Swiss German	Anomic	Chronic	16	Light	Light	Ischemic stroke	Left
8	36	F	Left (previously right)	12	Swiss German	Anomic	Chronic	108	Minimal	Light	Ischemic stroke	Left
9	30	F	Left	9	Swiss German	Broca	Chronic	130	Medium	Light	Ischemic stroke, Craniocerebral trauma	Left
10	47	M	Right	16	Swiss German	Anomic	Chronic	17	Minimal	Minimal	Craniocerebral trauma	Left
11	55	M	Right	13	Swiss German	Global	Chronic	217	Severe	Medium	Ischemic stroke	Left
12	74	M	Two-handed	12	Swiss German	Broca	Chronic	61	Medium	Medium	Haemorrhagic stroke	Left
13	27	M	Right	14	Swiss German	Anomic	Chronic	105	Light	Light	Ischemic stroke	Left
14	69	F	Right	10	Swiss German	Anomic	Post-acute	1	Light	Minimal	Brain tumour	Left
15	43	M	Left	29	Swiss German	Wernicke	Chronic	43	Severe	Light	Ischemic stroke	Left
16	67	M	Right	13	Swiss German	Anomic	Chronic	28	Minimal	Minimal	Ischemic stroke	Right
17	75	F	Right	9	Swiss German	Anomic	Chronic	25	Minimal	Minimal	Ischemic stroke	Left
18	60	M	Right	9	Swiss German	Anomic	Chronic	15	Minimal	Minimal	Ischemic stroke	Left
19	69	M	Right	19	Swiss German	Anomic	Post-acute	2	Light	Light	Ischemic stroke	Left
20	58	F	Right	12	Swiss German	Anomic	Post-acute	5	Minimal	Light	Haemorrhagic stroke	Right
21	42	F	Left	11	Swiss German	Broca	Chronic	140	Medium	Medium	Haemorrhagic stroke	Left
22	54	M	Two-handed	15	Swiss German	Broca	Chronic	120	Light	Medium	Ischemic stroke	Left
23	58	F	Right	13	Swiss German	Broca	Chronic	34	Medium	Medium	Ischemic stroke	Left
24	56	M	Right	16	Swiss German	Anomic	Chronic	65	Minimal	Light	Ischemic stroke	Left
25	84	F	Right (retrained to left)	10	Swiss German	Anomic	Chronic	258	Light	Light	Ischemic stroke	NA*
26	53	F	Right	1	Swiss German	Anomic	Chronic	142	Light	Light	Haemorrhagic stroke	Left
27	48	F	Right	17	Swiss German	Wernicke	Chronic	138	Medium	Medium	Ischemic stroke	Left
28	65	M	Right	16	Swiss German	Broca	Chronic	91	Minimal	Light	Ischemic stroke	Left
29	75	F	Right	10	Swiss German	Anomic	Chronic	78	Minimal	Light	Ischemic stroke	NA*
30	68	M	Right	9	Swiss German	Wernicke	Chronic	16	Light	Medium	Ischemic stroke	Left
31	62	M	Right	12	Swiss German	Wernicke	Post-acute	2	Medium	Medium	Ischemic stroke	Left
32	63	M	Right	9	Swiss German	Anomic	Chronic	14	Light	Light	Ischemic stroke	Left
33	67	M	Left	15	Swiss German	Broca	Chronic	124	Medium	Medium	Ischemic stroke	Left

• This information is missing because these patients did not provide any information.

Figure 1: Graphic representation of a drill, showing the use of shading to provoke the illusion of three-dimensionality and different colour tones to show the texture of the object.

Selection of words

Naming correctness and naming latencies are influenced by several linguistic aspects such as word frequency, word length, accent, image agreement and name agreement (Adlington, 2009; Alario et al., 2004; Barry et al., 1997; Bates et al., 2003; Kemmerer, 2014; Laiacona et al., 2001; Levelt et al., 1999; Menn & Bastiaanse, 2016; Meyer et al., 2003; Snodgrass & Vanderwart, 1980). To assemble a comparable image set, each German-language term needed to fulfil linguistic specifications: all of them had two syllables, a trocheic rhythm with accent on the first syllable, maximally two morphemes, and were low frequent according to "Swiss German vocabulary" (Leipzig Corpora Collection). Only active and full verbs and nouns displaying object names (no proper nouns or colours) were included and the concepts had to be imageable.

Graphic Representations and Photographs

The graphic representations were developed within the research team and created by trained designers. They were designed based on photographs chosen according to the defined image concept and bought on stock images platforms (iStock www.istockphoto.com and Getty Images www.gettyimages.ch) (Reymond et al., 2019). The following image features were defined as image concept and applied identically for photographic stimuli and graphic representations: Colour was used to emphasize the characteristics of the subject depicted and natural objects were shown in their most prototypical colour (Mohr, 2010; Wurm et al., 1993). Colour contrast (Brodie et al., 1991) was applied evenly within the set. All concepts were shown without background, centred on grey (5% black) background and in canonical view (Palmer, 1981). Size relationship was controlled within a category (as applied in the Snodgrass and Vanderwart image set, 1980) and small narrow objects were shown in 45° angle positions (Snodgrass & Vanderwart, 1980). Verbs were shown task-engaged (Thiessen et al., 2016). The graphic representations differed from the photographs in the sense that details that were not required for unambiguous recognition were simplified or omitted (e.g., labels on objects, patterns on garments, details of technical devices) (Biederman, 1987) (See Figure 2 as an example). All images were presented full screen on an 8.3 x 5.4-inch screen (diagonal size 10 inches), had a resolution of 224 dpi, and were presented in RGB colour space.

Figure 2: Depiction of the verb "diving". On the left as a photograph (*iStockPhoto.com, 487542208*, 2015), on the right as a graphic representation.

Additionally, specific decisions were made to define the style of the graphic representation: No outline was used around the figures, therefore trying to avoid giving the image a schematic appearance and to differentiate the image style from the type of black-and-white line drawings. Textures were implemented in the form of different colour shades and shapes (Brodie et al., 1991; Rossion & Pourtois, 2001), three-dimensionality was simulated by the use of shading and gloss spots (Adlington, 2009; Rossion & Pourtois, 2001). Further specific criteria were defined separately for the depiction of nouns and verbs (See List 1 in Appendix: https://osf.io/kf7gv/?view_only=33c8687aa4e94907adec776d57c67922).

Image validation

To ensure the homogeneity of the stimuli used, the graphic representations were controlled for image agreement, visual complexity, and name agreement prior to the main experiment in two related image validation studies. These variables were chosen because they have been shown to provide relevant information on the development of stimuli depicting concrete nouns (Fiez & Tranel, 1997; Snodgrass & Vanderwart, 1980). Sixty-two students from the FHNW Academy of Art and Design (23 males, 35 females, 4 without gender specification, *M*age = 25.6, *SD* = 6.3) rated the 128 graphic representations. Every image was shown separately on a computer screen. A field to write the name as well as two 5-point scales were presented underneath the image. Participants were first asked to name in one word what they saw in the image (name agreement). Secondly, participants rated the number of details of the image presented (visual complexity) (1=very simple, 5=very complex), which was defined as a measure of complexity in terms of the number of lines, colours, and areas in the image but not of the object itself. Thirdly, to rate image agreement participants were asked to indicate the extent to which the image corresponded to their own mental idea of the concept (1=very low agreement, 5=very high agreement). The photographic stimuli were not included in the analysis as the results were expected to be similar to the graphic representations. The results of the pre-test analysis were used to adapt the graphic representations not fulfilling the requirements before their use in the main study. (For a detailed description of this procedure and the adaptations see List 2 and 3 in the Appendix).

Oral name agreement of the stimuli was examined in a second image validation study including 123 adults (50 males, 72 females, *M*age = 41.6, *SD* = 18.5) and was assessed with the percentage of correctly answered items and the H-statistic (Snodgrass & Vanderwart, 1980). While higher H-statistic values indicate lower name agreement, these scores were used to test the dominant term attributed to an image.

Sets

The photographs and graphic representations were compiled into eight different sets, in which the image type (photograph/graphic representation) and the word class (nouns/verbs) were controlled. Item listing was semantically and phonemically controlled for as well as for colour to ensure maximal semantic, phonemic and/or pictorial distances between successive items (Mohr, 2010). Besides the eight trial items, each set contained 64 image stimuli, half of the images showed verbs, the other half nouns (Székely et al., 2005). Half of the terms were shown as graphic representations and the other half as photographs. The order of image types was randomized, yet such that within a set, the terms were presented as a photograph the same number of times as they were presented as a graphic representation. The 64 images were divided into four blocks of 16 images. Depending on the set, either nouns were presented in the first two blocks and followed by two blocks of verbs or vice versa. Within each block, the word class was not changed, but the terms were presented randomly as photographs or graphical representations. Participants saw each term only once, either as photograph or as graphic representation. The sets were assigned randomly to the participants but ensuring that all sets were equally distributed among the participants.

Procedure

All participants completed the testing in a single session, which took 30-45 minutes for persons in the CG. For the PWA, the main testing took 30-60 minutes depending on the type and severity of aphasia, the screening-tests took an additional 15 minutes (with a break between screening-tests and main testing). PWA were tested at the facility of their language therapy. All other participants were tested at the FHNW University of Applied Sciences and Arts Northwestern Switzerland or in their private environment (due to the COVID-19 pandemic restrictions). The images were shown and responses were video, and audio recorded on an Android Tablet via a mobile app developed for the study. The examiner was seated next to the participant (in approximately 60 inches distance). Before starting the naming task of the main experiment, PWA completed two screening-tests: the Pyramids and Palm Tree Test (PPT; Howard & Patterson, 1992) and a shortened version of the Coloring of Pictures Test (CoPT; De Renzi et al., 1972). The CG did not complete the screening-tests.

The main experiment started with a standardized oral instruction of the naming task, followed by an example task. The introduction and the example task were repeated until the participant understood the task correctly. Each stimulus was presented with the App in the following manner: A fixation cross was presented for 500 milliseconds followed by a blank page for 150 milliseconds before the test item was presented for 10 seconds full screen on the tablet. After that a blank page was shown again for the maximum of five minutes, in order to provide a short break for the participant if needed (See Fig. 3). While the image was visible on the screen participants had to name the presented stimuli

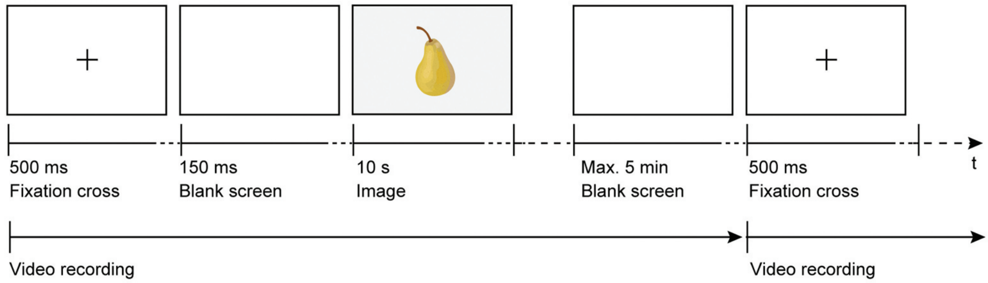

Figure 3: Example sequence of stimuli presentation with the mobile App.

according to the beforehand given instructions: "Please name the image as fast and as correctly as possible by using one single word." After the participant had given a response or was clearly not able to provide one, the examiner clicked to show the next image.

Measures

Screening-Tests: Colour Vision and Semantic Access

The Pyramid and Palm Tree Test (PPT; Howard & Patterson, 1992) and a shortened version of the Coloring of Pictures Test (CoPT; De Renzi et al., 1972) were conducted prior to the main experiment to measure the capacity to access semantic information about pictures (PPT) and unimpaired colour vision (CoPT) in participants with aphasia. To pass the Pyramids and Palm Tree Test (PPT; Howard & Patterson, 1992) a minimum of 90% of the 47 items (adapted following Callahan et al., 2010; Mohr, 2010) had to be answered correctly. Coloring of Pictures Test (CoPT; De Renzi et al., 1972) was considered successful when three out of four colours were assigned correctly.

Naming correctness

In our study we distinguished between invalid and valid responses. Invalid responses, and thus those excluded from the data set, are described in the section "invalid responses" (see below). The valid ones were again divided into correct and incorrect responses. Responses were considered correct if the participant provided exclusively the previously determined and therefore linguistically controlled reaction to the stimuli within 10 seconds. Responses that were synonyms, diminutives, superordinate terms, more specific words (e.g., "rain jacket" for "jacket"), plurals, metonyms, and cohyponyms of the target word, paraphasias, hesitations as well as multi-word responses such as self-corrections, conduite d'approches, and responses, in which the article of the term was mentioned, were coded as incorrect responses.

Naming latency

Naming latencies were only calculated for correct responses. Each naming latency was calculated as the interval between the onset of visual naming stimulus on the tablet screen and the onset of correct target response. Naming latencies were manually measured using the speech analysis program Praat (Boersma, 2001) which allows acoustic analysis by presenting waveform and spectrogram of audio data.

Invalid responses

Zero responses (no response within 10 seconds or "I don't know") and technical errors, such as recording failure or loud noises, were excluded from the data set (Alario et al., 2004; Vorweg et al., 2019).

Data analysis

The data was analysed using generalized linear mixed models (GLMM) and linear mixed models (LMM). These were estimated using maximum likelihood estimation offered by the statistical software R and the lme4-package (Bates et al., 2015). Tests were executed by applying the lmerTest package (Kuznetsova et al., 2017). The models were built in a forward selection approach. The best model fit was defined by running an F-Test on the Akaike information criterion (AIC) and Bayes information criterion (BIC).

Naming correctness

To analyse the data regarding the naming correctness, generalized linear mixed models with binomial distribution and logit link function were used. The final model contained the fixed effects of group (PWA vs. CG), image type (graphic representation vs. photograph), and word class (verb vs. noun). Participants were included as a random intercept.

Naming latencies

The naming latencies were analysed with a linear mixed model with a Gaussian distribution and a link function. In the final model grouping variable (PWA vs. CG), image type (graphic representation vs. photograph), word class (verb vs. noun) were included as fixed effects without considering interactions, as well as a random intercept for each participant.

Results

Naming correctness

A total of 8448 responses were collected during the naming task of our study. Out of the original observations, 1396 responses (17%) were excluded from statistical analysis. Out of these, 389 (18%) were excluded due to technical problems (e.g., shifting up too early) or noise (e.g., coughing). Because name agreement (NAA) can affect both naming correctness and latency (Alario et al., 2004; Laiacona et al., 2001; Kemmerer & Tranel, 2000), we also excluded items a posteriori which had obtained insufficient NAA (i.e., too low percent agreement and/or high H-values) in our second image validation study on oral name agreement. This affected a total of 16 items and resulted in the exclusion of 1007 (72%) responses. As a result, 7007 valid responses were included in the final analysis of our study. Of the 7007 responses included, 3343 (48%) were given from PWA and 3664 (52%) were provided by the CG.

Participants in the CG named concepts significantly more correctly than PWA (z = -9.21, $p < .001$) and nouns were named significantly more correctly than verbs (z = -5.71, $p < .001$). The model revealed no significant main effect for the image type (z = -0.01, $p = .991$). The best fitting model did not include any interaction effects. As can be seen on Figure 4, the CG named nouns depicted as photographs equally to graphic representation: *M*Photo = 86.04 (*SD* = 8.40) vs *M*Graphic = 86.98 (*SD* = 7.50). Verbs were also named equally, although less correct than nouns: *M*Photo = 82.27 (*SD* = 9.40) vs *M*Graphic = 79.50 (*SD* = 10.60). In the PWA group, the mean of correct responses was slightly higher for naming nouns presented as graphic representation, although the model did not reveal a significant difference between the two image types: *M*Photo = 53.73 (*SD* = 21.00) vs *M*Graphic = 56.03 (*SD* = 18.47). The mean for naming verbs depicted as graphic representation correctly was also higher than for naming verbs depicted as photographs (but not on a significant level): *M*Photo = 48.60 (*SD* = 20.96) vs *M*Graphic = 49.23 (*SD* = 22.39). We additionally investigated whether the difference in years of education between the CG and PWA had an impact on naming correctness. However, adding the factor years of education did not influence the model ($z = 0.291$, $p = .771$).

Naming latencies

In average the CG named images faster when naming nouns and slower in average when naming verbs. PWA named nouns presented as photographs or graphic representations faster than verbs (See Table 2 for all Descriptive Statistics on naming latencies).

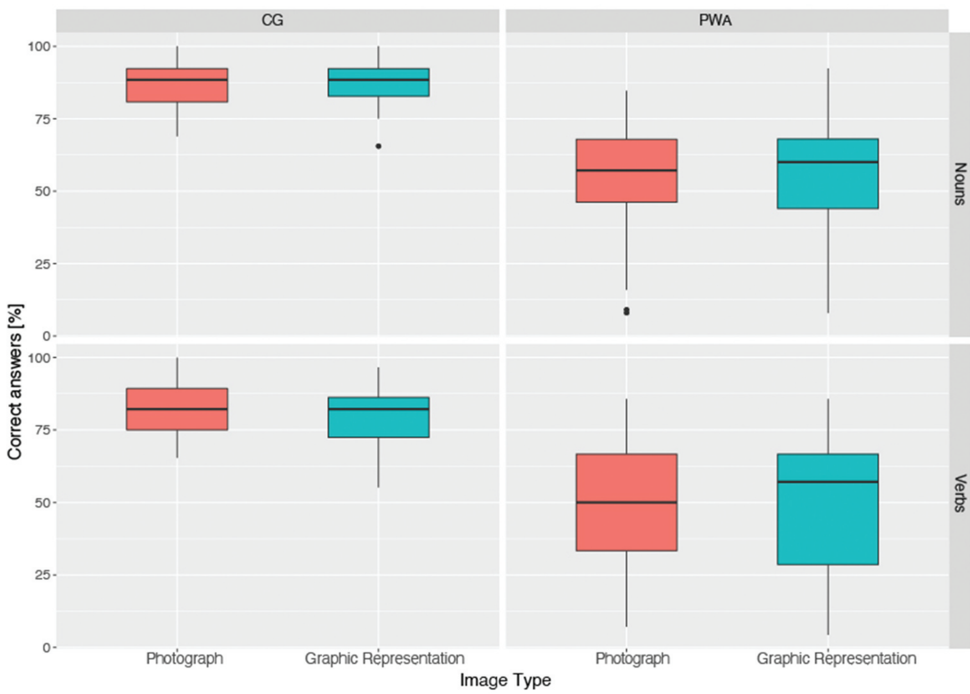

Figure 4: Naming correctness over all conditions for photographs and graphic representations. The box represents the interquartile range (IQR) ranging from the first to the third quartile and therefore the middle 50% of the data. The horizontal line indicates the median. Outliers are marked as dots and exceed the limit 1.5xIQR as defined by Tukey (1977).

Table 2 :Means and standard deviations for naming latencies in milliseconds for terms depicted as photographs vs. as graphic representations. Separated for PWA and CG and for nouns and verbs.

		PWA			CG		
Image Type	Word Class	*n*	*M*	*(SD)*	*n*	*M*	*(SD)*
Photo	Nouns	33	1356.50	(396.43)	33	1011.02	(337.18)
	Verbs	33	1448.91	(387.44)	33	1129.83	(379.57)
Graphic Rep.	Nouns	33	1386.84	(426.57)	33	1012.62	(352.51)
	Verbs	33	1455.63	(431.59)	33	1137.50	(396.96)

Note. Image Type = term presented as photograph or graphic representation; Word Class = nouns or verbs; PWA = persons with aphasia; CG = control group; *n* = number of participants; *M* = mean; *SD* = standard deviation.

Regarding naming latencies, again two significant main effects were found, one for group ($t = 8.33$, $p < .001$) and one for word class ($t = 10.69$, $p < .001$): It took a participant significantly longer to answer if the stimulus was a verb. Also, as expected, PWA responded significantly slower than the CG. There was no significant effect for the fixed factor image type ($t = 0.63$, $p = .529$) (See Figure 5). Similarly, as for naming correctness, the factor years of education did not influence naming latencies ($t = -1.74$, $p = .084$).

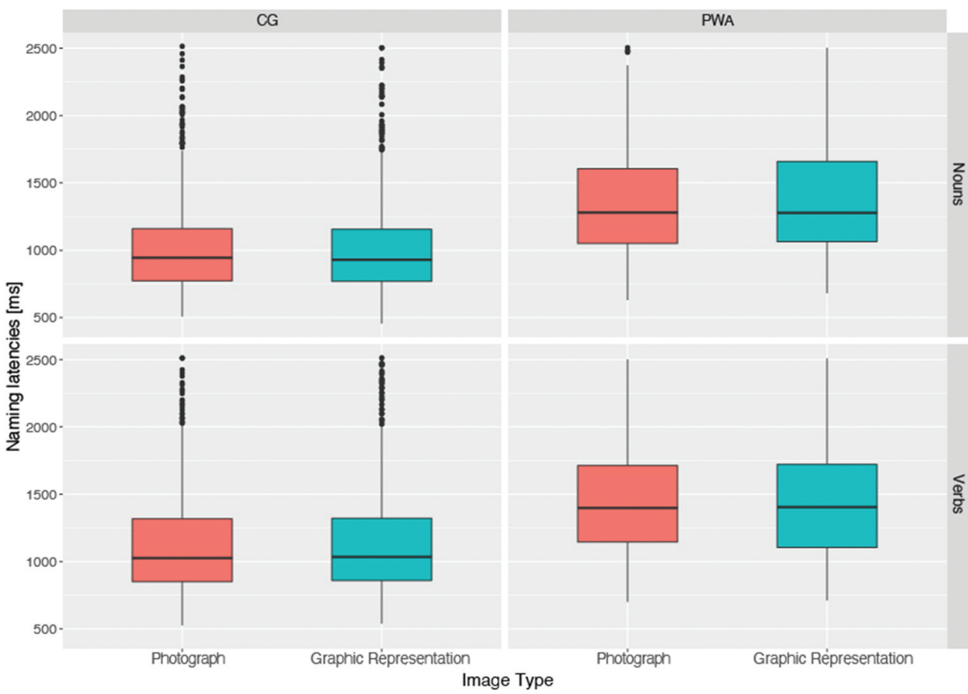

Figure 5: Naming latencies in milliseconds over all conditions for photographs and graphic representations. The box represents the interquartile range (IQR) ranging from the first to the third quartile and therefore the middle 50% of the data. The horizontal line indicates the median. Outliers are marked as dots and exceed the limit 1.5xIQR as defined by Tukey (1977).

Discussion

In this study a stimulus set of graphic representations depicting nouns and verbs was developed. Naming correctness and naming latencies of both PWA and the CG were measured and compared to naming correctness and latencies of photographic stimuli. Correctness and latencies differed as expected between the groups, with the CG naming images more correctly and faster than PWA. The two image types, however, did not have a significant effect on naming performance. This is in contrast to past studies that have shown effects of image type on naming performance and communication behaviour (Bisiach, 1966; Ho et al., 2005; Ma et al., 2009). Specifically, when photographs have been compared to black-and-white line drawings results revealed an advantage for coloured photographic stimuli over black-and-white line drawings (Griffith et al., 2014; Heuer, 2016). But these studies have compared image types that differ in relevant image features like colour, texture, and shading. Based on the results of our study, we showed that when image stimuli are controlled for features that favour naming performance (e.g., colour, shading, texture) the differences in naming correctness and latencies between image types disappear. Image types used in linguistic or psychological research offer specific advantages (Souza et al., 2020). The use of line drawings in empirical research as well as in various clinical contexts has a long tradition. The widespread use of this image type also reflects, besides the technically simpler production in past times, the intention to control for effects of conflicting image features (e.g., Snodgrass & Vanderwart, 1980). In more recent years, the use of photographic stimuli has increased because they have become easily accessible and can be produced at relatively low cost. With our work, we show that image sets could include a combination of different image types. However, image features need to be controlled. Therefore, when creating or selecting image sets, but especially when using image stimuli in research and clinical practice, it is of fundamental importance to ensure transparency concerning image characteristics that influence naming performance. This again allows for the conclusion that the results of aphasia diagnosis and therapy—which are based on naming pictures—are due to the language disorder and not to picture effects.

The development of high quality, conceptually clear image material requires a methodologically sound approach. The image stimuli presented in this study were created according to a clearly defined process that was structured into different phases. First, we determined image features that have been shown through empirical research to facilitate naming. Based on this, we defined an image concept describing which image characteristics should be applied to the images (e.g., colour, texture, shading). In a further step, we applied these image features uniformly to the images within our set and adapted those stimuli where the image features could not be applied directly. Applying the defined image characteristics to all stimuli of the set requires the expertise of trained designers who can produce high quality representational images with relative ease (Kozbelt et al., 2010). With this approach, we have incorporated empirical findings into the production of image material. Although many image features can be controlled in this way, it is not possible to develop images solely based on studied image features. Because every image is different and may contain image characteristics that have not (yet) been examined. Thus, there is a need for further in-depth investigations of image features that result from theoretical assumptions, but also from the process of image making. The endeavour of creating a methodologically controlled set of image stimuli requires time, knowledge, as well as resources. Interdisciplinary collaboration in the production of image stimuli is therefore essential in our view and should not be underestimated in the research process.

Our results further showed that word class affected naming in that sense, that nouns were named significantly more correctly and faster in the CG as well as in PWA. This is in line with previous studies, showing slower naming responses for verbs (Bastiaanse et al., 2003; Bastiaanse & Jonkers, 1998; Mätzig et al., 2009). We found no significant differences in naming performance of verbs in regard to image type. However, the results on naming correctness in PWA—although not on a significant level—showed that graphic representations were named more correctly on average than photographs. This could suggest that a reduced and translated version of actions perceived in reality (described in our paper as graphic representations) could be an advantage for depicting verbs. At the same time the response correctness in PWA varied more in naming graphic representations than in naming photographs of verbs which shows that there are greater interindividual differences in correctly naming graphic representations than in naming photographs of this word class. However, we could not conclusively demonstrate the advantages of graphic over photographic stimuli on naming performance of verbs. Further research is needed to clarify the suitability of less detailed images for the representation of verbs. Anyway, the predominant use of line drawings to represent verbs (Akinina et al., 2015; Khwaileh et al., 2018; Masterson & Druks, 1998; Székely et al., 2004) suggests that it might be easier to *produce* drawings for this word class than photographs. In our study, the large variance in naming an action correctly might be attributed to a varying degree of precision of the image itself, denoting the general difficulty to depict verbs in comparison to objects. This is also reflected in the general underrepresentation of picture stimuli for verbs relative to those for objects (Akinina et al., 2015), though this gap has been addressed in the last two decades by the addition and elaboration of picture stimuli depicting verbs (Akinina et al., 2015; Fiez & Tranel, 1997; Masterson & Druks, 1998; Székely et al., 2004). Considering that more image sets need to be produced that depict verbs, what is needed above all is more knowledge on which image features (e.g., colour, controlled size, shading, texture) are most important for depicting verbs. In our study, we have included image features that facilitate naming to the depictions of nouns and verbs equally. Therefore, it remains unclear which image features were especially helpful for naming nouns, and which were relevant for naming verbs. Future research needs to investigate image characteristics separately regarding their impact on naming different word classes.

Limitations and future studies

In our study, we have shown that drawings (in our case graphic representations), when they include image features that facilitate naming like colour, texture, and shading, are named at least comparably to photographic stimuli. However, some limitations need to be addressed.

The group of PWA included in our study was heterogeneous. Future work is needed which investigates whether certain image types—and specific image features—are particularly suitable for a certain type of aphasia. In addition, it could possibly be that individuals, regardless of their language impairment, show a preference for an image type which could have an effect on naming performance. Moreover, the fact that PWA were presented with line drawings during the screening-tests (PPT; Howard & Patterson, 1992 and CoPT; De Renzi et al., 1972) may have influenced their naming of graphic representations compared to the participants in the CG. It is possible that the presentation of black-and-white line drawings before the main experiment induced some ease in naming drawings in general in the PWA. To fully control for this aspect, different types of pictures should be included in the screening-tests in the future, or these tests should be conducted after the main experiment rather than before it. Finally, we created an image set with limited scope. In order to use the set in aphasia therapy, it would need to be expanded to provide a larger number of stimuli. In particular, a greater cultural and ethnic diversity must be considered for the depicted persons engaged in an action. Given the fact that stimuli that were developed decades ago and therefore do not represent diversity (e.g., The Cookie Theft Picture from the Boston Diagnostic Aphasia Examination, Goodglass & Kaplan, 1972) are still predominantly used, image stimuli that reflect the diverse world in which we live are needed. Consideration of cultural and ethnic diversity in standardised images used in aphasia diagnosis and therapy must thus be given greater priority and implemented more consistently in the production of stimuli in the future.

Conclusion

In aphasia practice, controlled and consistent image materials are needed for therapy and diagnosis. Images that are carefully controlled for image features facilitating naming are also required in research to study language processing in aphasia. Therefore, we emphasize the importance of image features which need to be explored transparently for use with PWA. As we have shown in our study, different types of images can have similar effects on naming performance. We conclude by saying that in aphasia practice, image sets can be composed of diverse types of images according to their availability. However, this does not mean that images can be randomly arranged (e.g., mixing black-and-white with coloured image stimuli or line drawings with images that include shading). Rather, it foregrounds the importance of being aware that differences in colouring, visible texture, or size of a stimulus within a set can affect naming performance. Considering how much time and effort PWA invest in relearning and training language, we advocate for methodologically controlled images that are produced or selected with great care.

Acknowledgments

The authors thank the FHNW University of Applied Sciences and Art Northwestern Switzerland for funding E-Inclusion, the study participants for their motivated participation, and the speech therapy teams and departments of the practice partners for their dedicated collaboration: REHAB Basel, Reha Rheinfelden, Bad Schinznach (Privat-Klinik Im Park); Cantonal Hospitals Aarau, Baden, Baselland, Graubünden and Olten (Solothurn Hospitals); Hospitals Schaffhausen and Zofingen; University Hospital Zurich (Clinic for Neurology) and Geriatric Medicine FELIX PLATTER; Stadtspital Waid and Triemli; speech therapy practices Fanny Dittmann-Aubert, Isabelle Facchini-Baumann, LogoTreffpunkt, mund'art, rundum therapie, Petra Dietiker and Unterstrass. The authors would also like to thank the team of designers from the Academy of Art and Design FHNW: Lena Meier, Sarah Schiltknecht, Laurent Poffet, Alisa Strub, and Karen Trachsel.

Disclosure of Interest

This work was supported by the FHNW University of Applied Sciences and Art Northwestern Switzerland as part of a Strategic Initiative 2018 - 2020. The authors report no conflict of interest.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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