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The effect of static versus dynamic depictions of actions in verb and sentence production in aphasia

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ABSTRACT

Background: There is a shortage of material for the treatment of verb and sentence production in persons with aphasia (PWAs). In therapy, pictures or photographs depicting actions are often used, even though the meaning of certain verbs clearly involves movement. This aspect of movement is difficult to depict on static material. In a case study, Druks, J., & Shallice, T. (2000). Selective preservation of naming from description and the “Restricted Preverbal Message”. *Brain and Language*, 72, 100–128. doi:10.1006/brln.1999.2165 reported a patient who had difficulties naming actions. However, when the actions were performed, the patient was better at naming performed actions compared to naming actions depicted in still pictures.

Aims: In the current study, we tested the hypothesis that PWAs are more accurate in naming verbs in isolation as well as in sentence context in a dynamic condition rather than in a static condition. In a second experiment, we examined whether the use of verbs that express specific types of movement has any influence on the production of verbs when using static and dynamic depiction. Verbs in three semantic categories were included, namely action verbs relating to arm, leg and face movements.

Methods & Procedures: In the first experiment, verb production was examined in a static (photographs) condition and a dynamic (videos) condition. An action-naming task and a sentence production task of 20 items each were administered to 18 PWAs. In the second experiment, an action-naming task of 60 items was administered to 13 PWAs.

Outcomes & Results: PWAs scored significantly better in the dynamic condition compared to the static condition on both the action-naming task and the sentence-production task in Experiment 1. Considering the three semantic categories that were considered in Experiment 2, PWAs only scored significantly better on the category “arm” in the dynamic condition as compared to the static condition.

Conclusions: These results suggest that semantic information of an action’s specific aspects, such as movement, is activated while watching an action. We assume that PWAs profit from this depiction of movement. This study implicates that in clinical practice, dynamic material, rather than static material, should be used in diagnosis and therapy involving action naming and sentence production.

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Introduction

In aphasia research, many studies have been done about object and action naming in persons with aphasia (PWAs). In 1998, Jonkers tested 76 PWAs, all experiencing more problems in action naming than in object naming. Also, Mätzig, Druks, Masterson and Vigliocco (2009) described 38 studies examining action and object naming in PWAs, published between 1984 and 2005. They concluded that 14% of the included 280 PWAs showed no difference between naming actions and objects, 11% had specific difficulties in naming objects, whereas 75% had specific problems in naming actions. Therefore, it can be concluded that disturbed action naming in PWAs appears more often as compared to object naming. However, the materials that are used to test object and action naming seem to be more suitable for noun retrieval than for verb retrieval. Most studies concerning verb and noun retrieval are conducted with static materials to depict objects and actions, where objects are static entities, but actions often involve movement.

For two decades, researchers have been examining the use of dynamic material in verb production. Berndt, Mitchum, Heandiges, and Sandson (1997) included 11 chronic PWAs, who were presented with tasks in static and dynamic conditions. They found no difference in action naming in a static versus dynamic condition. A few participants scored better in the dynamic condition, but it did not lead to a significant difference. Therefore, the authors concluded that the way of depiction does not influence action naming.

Tranel, Manzel, Asp, and Kemmerer (2008) included 78 participants with brain damage in a functional Magnetic Resonance Imaging (fMRI) study. They found that the participants were better in naming actions in a static condition rather than a dynamic condition. They argued that the participants had more time to look at the image in the static condition and, therefore, had more response time.

However, other studies report a difference in favour of the dynamic condition. In a case study, Druks and Shallice (2000) reported a participant with characterisations of Wernicke's aphasia. This participant experienced difficulties in action naming when actions were depicted in a photograph or picture. However, if the researcher acted out the actions, the participant had superior action naming compared to those same actions portrayed in pictures. The authors argued that the strengthened semantic context and information given by a more dynamic presentation was helpful to the participant.

Studies exploring the role of dynamic depiction in participants with dementia also reported a difference in favour of the dynamic condition. Fung et al. (2001) performed a study with 20 participants with Alzheimer's disease and found better scores in action naming in a dynamic condition as compared to a static condition. They argued that with static depictions, it is not possible to denote the complete action because actions often involve movements that cannot be captured in static depiction.

Finally, d'Honinckhun and Pillon (2008) described a participant with frontotemporal dementia with verb-retrieval problems. Verbs were retrieved significantly worse than nouns in a static condition. In a dynamic condition with videos, however, specific difficulties with action naming virtually disappeared and action naming proved to be equally as impaired as object naming.

Although some studies show the contrary, studies, especially on participants with dementia, show that participants scored better on action naming when action verbs were depicted in a dynamic condition. The explanation given for this effect was that with static depiction, certain features, such as the movement of the action, were only captured in the dynamic condition. The reason why the depiction of movement might be helpful relates to the neural representation of actions.

The neural representation of actions has been studied in the brain of non-language-disturbed participants. In some of these studies, actions from various semantic categories, for example, arm- and leg-related actions, have been differentiated. Hauk, Johnsrude, and Pulvermüller (2004) conducted an fMRI study with 14 non-language-disturbed participants. In a passive reading task, the participants had to read words from three different categories, namely actions related to arm (e.g., grabbing), leg (e.g., kicking) and face (e.g., licking). Action verbs from the category “face” appeared to activate inferior frontal premotor areas. Action verbs from the category “arm” activated the central frontal bilateral gyrus in the premotor cortex and the precentral gyrus in the motor cortex in the left hemisphere. Action verbs from the category “leg” activated dorsal areas in the left and central pre- and postcentral gyri and in the premotor cortex on the dorsal diameter. Hauk et al. (2004) found that activation of areas in the brain showed overlap when reading action verbs related to the arm and leg and actual finger and foot movements. However, tongue movements and reading verbs related to the face showed no overlap in activated brain regions. Tongue movement led mainly to activation in the premotor areas posterior of the areas activated when reading verbs related to the face. Yet, this could be explained because the category “face” did not only consist of actions of the tongue but also of other parts of the face, such as the jaws. This was not the case in the categories “arm” and “leg”. Actions in these categories always caused movement of both arm and hand and of both leg and foot. Hauk et al. (2004) concluded that reading verbs related to the categories “arm”, “leg” and “face” cause activation in the primary motor and premotor areas which are also activated when actually moving the foot, fingers and tongue.

These results indicate a somatotopic representation of the meaning of action verbs in the brain. Similar results were found in an earlier study to arm-, leg- and face-related actions (Pulvermüller, 2001; Pulvermüller, Härle, & Hummel, 2001). Tettamanti et al. (2005) found similar outcomes in an fMRI study in which non-language-disturbed participants listened to sentences in which actions were performed with the arm (e.g., “I grab a knife”), leg (e.g., “I kick the ball”) or the face (e.g., “I bite an apple”).

The role of the neural representation of these specific verb types is also examined in brain-damaged participants. Arévalo, Baldo, and Dronkers (2012), for example, conducted a study on 27 PWAs with left hemisphere strokes. They investigated whether lesions to key sensorimotor regions would preferentially impact the comprehension of stimuli associated with the use of the hand, mouth or foot. The PWAs were divided up in groups based on the localisation of the brain lesion. The participants were presented with pictures and words representing objects and actions typically associated with the use of the hand, mouth, foot or no body part at all. Arévalo et al. (2012) found that all PWAs, no matter which region the brain damage occurred, were less accurate on the foot-related items versus the foot-neutral items. They concluded that the foot-related

items were less salient than items referring to other body parts or perhaps not as easy to depict in two-dimensional drawings.

The role of neural representations is often explained within the embodied view of cognition. The embodied view of cognition argues that cognitive processes are rooted in the body's interaction with the world (Wilson, 2002). In studies that show that specific areas of the brain are activated when interpreting various types of verbs, it is assumed that semantic knowledge of actions is represented in the sensorimotor system of our brain. This relates to the embodied view of cognition. Neural systems that give access to semantic knowledge are also necessary for the perception of sensory modalities or the performance of actions. So, when someone sees another person performing a certain action, his own sensorimotor system, that is, the neural networks in the motor and premotor cortex, is involved in understanding the action (Rizzolatti & Sinigaglia, 2010). A variety of studies have shown that various brain areas are activated in the interpretation of the action depending on the specific semantic information that is part of the action (cf. Hauk et al., 2004; Kemmerer, Gonzalez Castillo, Talavage, Patterson, & Wiley, 2008).

Studies with brain-damaged participants have supplied evidence for the embodied view of cognition. In her study, Farooqi-Shah (2012) showed that PWAs were faster in naming arm-, leg- and face-related verbs when they were preceded by a related, somatotopic prime (e.g., *running* for *kicking*) or phonemic prime (e.g., *ka* [as in *cut*] for the target *kicking*) as compared to a neutral prime (unrelated noun). The results indicate that semantic knowledge for these actions is rooted in the sensorimotor system, leading to faster retrieval of actions due to somatic priming of knowledge.

The theory of embodied view of cognition has received criticism as its counterpart, the disembodied view of cognition, was introduced. According to this theory, concepts are not rooted in the sensorimotor system but are mainly considered as symbolic and abstract conceptual representations (Caramazza, Anzellotti, Strnad, & Lingnau, 2014; Chatterjee, 2010; Humphreys, Newling, Jennings, & Gennari, 2013; Mahon & Caramazza, 2008). In their study, Mahon and Caramazza (2008) provided an example of this disembodied view of cognition. A participant was presented with a hammer and was requested to demonstrate its use. According to the disembodied view of cognition, out of the visual input of seeing the hammer, the concept "hammer" is retrieved. That concept is an abstract and symbolic representation that is not constituted by information in the sensory and motor systems. This representation, once retrieved, will contact or "index" the relevant information in the motor system about how to manipulate the object. According to Mahon and Caramazza (2008) and Caramazza et al. (2014), all results, which served as evidence for the embodied view of cognition, can also serve as evidence for the disembodied view of cognition, because no study clearly proved that semantic information of actions is actually rooted in the sensorimotor system instead of abstract and symbolic representations.

Considering both the embodied and disembodied views of cognition, there is no unanimous outcome. Nevertheless, with respect to our current study, neither theory contradicts the fact that semantic information of specific aspects of an action, such as movement, is activated while seeing an action. We hypothesise that this extra semantic stimulation is helpful in retrieving the verb.

As mentioned earlier, studies exploring the difference between a static and dynamic depiction are contradictory. Berndt et al. (1997) found no significant difference between

a static and dynamic condition in 11 PWAs, although a few participants did show an advantage in the dynamic condition. Tranel et al. (2008), conversely, found a difference in favour of the static condition in an fMRI study with 78 brain-damaged participants. However, these participants got more time to respond in the static condition. This contradiction in favour of the static condition could be due to the increased, afforded reaction time. In a case study, Druks and Shallice (2000) found a significant difference in favour of the dynamic condition; however, their experiment compared pictures with gestures. d'Honinckhun and Pillon (2008) also found a difference in favour of dynamic depictions while this was a case study with a participant suffering from dementia. Fung et al. (2001) also found similar results in a larger group of participants with Alzheimer's disease.

Besides the contradictory outcomes and the various groups of participants included in all the studies mentioned earlier, naming actions are the common factor examined here. However, in therapy, verbs are trained in sentence context and not in isolation. Bastiaanse and Jonkers (1998) found in their study that there is no correlation between scores on action naming and sentence production. The performance on verb retrieval in sentence production in PWAs is therefore important for clinical practice as well.

In the current study, we, therefore, tested the hypothesis that PWAs are more accurate in naming verbs in isolation as well as in sentence context in a dynamic condition rather than in a static condition. The use of photographs and video materials was compared using the same items in the static and dynamic condition. Factors that have been found to be of influence on verb retrieval were controlled for, such as transitivity (Jonkers, 2000) and instrumentality and name relation to a noun (Jonkers & Bastiaanse, 2007).

In a second study, with reference to the outcomes of the first study, we examined whether the use of verbs that express specific types of movement is of any influence on the production of verbs in isolation, using static and dynamic depiction. In line with the results found by Hauk et al. (2004), three semantic categories were considered: action verbs related to arm, leg and face.

Experiment 1

Methods

Participants

Eighteen PWAs were included in this study, of which, 13 males and 5 females. The mean age of the group was 55 years (range 39–79 years). All participants were native speakers of Dutch and suffered from a left hemisphere stroke. The participants' mean time post-onset was 12 months (range 2–74 months). Both fluent and non-fluent-speaking PWAs were included. All PWAs were diagnosed with the Aachen Aphasia Test (Graetz, De Bleser & Willmes, 1992). The individual data are provided in Table 1.

A control group of non-language-disturbed participants ($n = 16$), including 6 males and 10 females, was tested. The mean age of the group was 52 years (range 31–67 years). The individual data are provided in Table 1.

Table 1. Participant characteristics of the first experiment.

Participant	Age (years)	Gender	Aethiology	Time post onset (months)
PWAs				
P1	39	F	iCVA lh	6
P2	42	M	IC lh	7
P3	63	M	iCVA lh	3
P4	64	M	iCVA lh	4
P5	43	M	iCVA lh	2
P6	56	M	iCVA lh	8
P7	50	M	iCVA lh	4
P8	58	M	iCVA lh	2
P9	79	M	iCVA lh	74
P10	46	F	iCVA lh	13
P11	65	M	iCVA lh	7
P12	42	F	iCVA lh	2
P13	59	F	iCVA lh	29
P14	52	M	iCVA lh	8
P15	57	F	iCVA lh	34
P16	52	M	iCVA lh	12
P17	66	M	iCVA lh	2
P18	65	M	iCVA lh	6
Non-language disturbed participants				
CG1	54	F		
CG2	57	F		
CG3	37	F		
CG4	67	M		
CG5	33	F		
CG6	53	F		
CG7	58	M		
CG8	56	M		
CG9	57	M		
CG10	53	M		
CG11	31	F		
CG12	43	F		
CG13	53	F		
CG14	62	F		
CG15	61	M		
CG16	58	F		

M: Male; F: female; iCVA: ischaemic cerebrovascular accident; IC: intracerebral haematoma; lh: left hemisphere; PWA: persons with aphasia.

Materials

An action-naming task and a sentence-production task of both 20 items were administered in both a static (photographs) and a dynamic condition (videos). The verbs that were used in the static and dynamic version were identical. The tasks were presented on a computer screen.

Half of the verbs were high-frequency verbs, the other half were low-frequency verbs (Burnage, 1990). Verbs with a logarithmic frequency of one or higher were categorised as high frequent. Also, the items were controlled for transitivity, instrumentality and name-relation to a noun. The items are provided in Appendix 1.

The duration of the video clip was 4 s for each item. The video clips were soundless and filmed in front of a white wall to create as little distraction as possible; however, verbs that were inextricably linked to a certain environment (e.g., to fry and to rake) were filmed in matching backgrounds (e.g., kitchen and garden).

The photographs were stills cut from the video clips that were used in the dynamic task. The photographs depicted the most recognisable moment of the action. The

researchers determined this moment. To decide if the photographs were indeed recognisable, a pretest was administered among 12 non-language-disturbed participants. The participants were requested to name the action. If one or more participants did not name the depicted action correctly, the action was not included in the experiment. The participants included in this pretest did not participate in the control group.

Procedures

Each participant did two sessions, with an interval between 1 and 2 weeks. Half of the participants started with the static condition in the first session, followed by the dynamic condition in the second session. The other half started with the dynamic condition in the first session. The item order in the dynamic and static condition was identical. Within each session, the participant started with the action-naming task followed by the sentence-production task, because the action-naming task was considered the easier task. Each task started with two practice items. During the practice items, the instructor was allowed to correct the participant if the instruction was not carried out correctly. During the administration of the test items, the instructor was not allowed to provide any kind of help. The participant was given the following instruction: "You will be shown a number of video clips/photographs. Can you tell me in one word what the person is doing?" The instruction for the sentence production task was: "You will be shown a number of video clips/photographs. Can you tell me in a sentence what this person is doing?"

The tasks were performed on a computer under an instructor's supervision. The instructor showed the participant a video clip or photograph, which automatically disappeared from the computer screen after 4 s. A black screen was presented until a response was given. Repeating an item was only permitted if an external interruption occurred. Furthermore, no repetitions were permitted. If no response was given, the researcher decided when to move on to the next item. During the task, the instructor and the participant were the only ones present in the room. All answers were recorded on a voice recorder and were transcribed afterwards.

Data analyses

The number of correct answers was counted and every correct answer was rewarded with one point. In both tasks if the correct verb was produced regardless of form or regardless if the verb was placed in a (correct) sentence, the participant was rewarded with one point. Slight phonological errors were not counted as incorrect. A response with a resemblance of at least 2/3 of the target item was considered a slight phonological error. However, if a slight phonological error resulted in the production of another existing verb, the response was counted as incorrect. For example, if the response on the item "to walk" was to "talk", than this did not count as a slight phonological error but was counted as incorrect. Semantic errors were counted as incorrect. Synonyms were counted as correct.

To account for an effect of test condition, a paired *t*-test was used to compare the scores.

Table 2. Mean scores of the PWAs and the control speakers with standard deviation (*SD*).

	PWAs Mean (<i>SD</i>)	Controls Mean (<i>SD</i>)
Static action naming	13.89 (3.98)	18.25 (1.57)
Dynamic action naming	14.94 (3.61)	19.01 (1.23)
Static sentence production	13.50 (4.60)	19.38 (0.81)
Dynamic sentence production	14.11 (3.40)	19.06 (1.44)

PWA: Persons with aphasia.

Results

The scores for both the PWAs and the non-language-disturbed participants are provided in Table 2. The non-language-disturbed participants scored between 15 and 20. There was no significant difference between the static and dynamic condition for both the action-naming ($t(15) = -1.399, p = 0.185$) and sentence-production task ($t(15) = 0.924, p = 0.370$). Therefore, the scores of the non-language-disturbed participants are further-more left out of consideration.

PWAs were able to produce significantly more correct reactions in both the action-naming task ($t(17) = -2.538, p = 0.021$) and the sentence-production task ($t(17) = -2.502, p = 0.023$) in the dynamic condition as compared to the static condition. The scores are depicted in Figure 1.

Experiment 2

Methods

Participants

Thirteen PWAs were included in this study, of which, 10 were male and 3 were female. The participants included in this experiment did not participate in the first experiment.

Figure 1. Experiment 1, group results for PWAs, *: significant difference ($p < 0.05$).

Table 3. Participant characteristics of the second experiment.

Participant	Age (years)	Gender	Aetiology	Time post onset (months)
PWAs				
A1	64	M	iCVA lh	8
A2	72	M	iCVA lh	9
A3	64	M	iCVA lh	14
A4	68	M	iCVA lh	20
A5	55	F	iCVA lh	10
A6	72	M	iCVA lh	54
A7	61	M	iCVA lh	2
A8	77	M	iCVA lh	51
A9	69	M	iCVA lh	57
A10	46	M	iCVA lh	59
A11	40	F	iCVA lh	39
A12	71	M	iCVA lh	23
A13	67	F	iCVA lh	47
Non-language disturbed participants				
C1	56	F		
C2	56	M		
C3	55	F		
C4	56	M		
C5	51	F		
C6	58	M		
C7	56	F		
C8	57	M		
C9	56	F		
C10	58	F		
C11	60	M		
C12	51	F		
C13	53	M		
C14	58	M		

M: male; F: female; iCVA: ischaemic cerebrovascular accident; lh: left hemisphere; PWA: persons with aphasia.

The mean age of the group was 63 years (range 40–77 years). All participants were native speakers of Dutch and suffered from a left hemisphere stroke. The mean time post-onset was 29 months (range 2–59 months). All participants were diagnosed with the Aachen Aphasia Test (Graetz, De Bleser & Willmes, 1992). The individual data are provided in Table 2.

A control group of non-language-disturbed participants ($n = 14$) including seven males and seven females was tested. The mean age of the group was 55 years (range 51–60 years). The individual data are provided in Table 3.

Materials

An action-naming task containing 57 items was administered in both a static (photographs) condition and dynamic (videos) condition. The verbs that were used in the static and dynamic version were identical. The items were divided into three categories; namely the category “arm” verbs ($n = 20$), “leg” verbs ($n = 17$) and “face” verbs ($n = 20$).

In order to divide the action verbs into the three categories, a pretest was administered among 10 non-language disturbed participants, including 6 males and 4 females, with a mean age of 39 (range: 21–66 years). The participants were requested to define whether the presented verbs reminded them of their arm/hand, leg/foot or face. If at least 8 out of 10 participants categorised the action in the same category, the action was

included in the experiment. The verbs were controlled for transitivity, instrumentality and name relation to a noun. All items are provided in Appendix 2.

Procedure

There were two sessions per participant, with an interval between 1 and 2 weeks. Each session, a task of 60 items, was administered including 3 practice items, 1 of each category. A break was permitted after 30 items. The participant indicated when he or she was ready to proceed. During the task, the instructor and the participant were the only persons present in the room.

Eight participants started with the static condition in the first session, followed by the dynamic condition in the second session. The other five participants started with the dynamic condition in the first session. In the control group, seven participants started with the static condition, followed by the dynamic condition 1 week later. The other seven participants started with the dynamic condition in the first session. There were two versions of each task with a different order of the items.

The participants received the same instructions that were used in the first experiment. The tasks were performed on a laptop controlled by the instructor. The instructor showed the participant a video clip or photograph, which automatically disappeared from the computer screen after 4 s. A black screen was presented until a response was given. Then for 1 s, a white fixation point in the form of a plus sign appeared on a black screen right before the next item appeared.

As in Experiment 1, repeating an item was only permitted if an external interruption occurred and if no response was given the researcher decided when to move on to the next item.

All answers were recorded on a voice recorder and were transcribed afterwards.

Data analysis

The scoring was the same as in Experiment 1. The total scores were determined and per participant converted into percentages because the amount of items per category was not equal.

To account for an effect of test condition in Experiment 1, a paired *t*-test was used. In Experiment 2, a one-way ANOVA was used to establish any differences between categories. A paired *t*-test was used to determine whether there was any difference in scores of the PWAs within the three categories between the static and dynamic condition.

Results

The mean scores of the PWAs and the non-language-disturbed participants are given in percentages in Table 4.

The mean scores of the non-language-disturbed participants are above 90%. The scores are depicted in Figure 2. There was no significant difference between the static and dynamic condition ($t(14) = 1.94$, $p = 0.07$). Therefore, the scores of the non-language-disturbed participants are furthermore left out of consideration. PWAs were

Table 4. Mean scores of the PWAs and control speakers with standard deviation (SD) in both conditions.

	PWAs Mean (SD)	Controls Mean (SD)
Static	66.77 (12.00)	90.23 (5.23)
Dynamic	72.38 (10.25)	92.98 (5.29)

PWA: persons with aphasia.

Figure 2. Experiment 2, group results for PWAs, *: significant difference ($p < 0.05$).

Table 5. Mean scores of the PWAs with standard deviation (SD) on the three verb categories in both conditions.

Static condition	Mean (SD)	Dynamic condition	Mean (SD)
Arm verbs	65.38 (18.10)	Arm verbs	76.54 (13.29)
Leg verbs	63.92 (11.27)	Leg verbs	67.92 (10.73)
Face verbs	71.54 (13.90)	Face verbs	73.08 (13.15)

able to produce significantly more correct reactions in the dynamic condition as compared to the static condition ($t(12) = 2.34$, $p < 0.05$).

The mean scores of the PWAs on the three categories are given in percentages in Table 5. PWAs were able to produce significantly more correct reactions in the category “arm” in the dynamic condition as compared to the static condition ($t(12) = 2.68$, $p < 0.05$). There were no significant differences found between the static and dynamic condition “leg” ($t(12) = 1.16$, $p = 0.27$), and between the static and dynamic condition “face” ($t(12) = 0.52$, $p = 0.61$). The scores are depicted in Figure 3.

Both in the static condition ($F(2,36) = 0.95$, $p = 0.38$) and dynamic condition ($F(2,36) = 1.58$, $p = 0.22$), there was no significant difference in the scores across the three categories.

Conclusion and discussion

In the current study, we investigated whether PWAs are more successful in action naming and sentence production in a dynamic rather than static condition. The group

Figure 3. Experiment 2, results per category in PWAs, *: significant difference ($p < 0.05$).

of PWAs scored significantly better in the dynamic condition as compared to the static condition on the action-naming task. This difference was not found in the group of non-language-disturbed participants.

The results of the current study are consistent with earlier studies considering the effect of dynamic depiction (Druks and Shallice, 2000; d'Honinchtun & Pillon, 2008; Fung et al., 2001). However, the group of PWAs in this study also scored significantly better on the dynamic condition of the sentence-production task in comparison with the static condition. This aspect was not examined until now and is very relevant for clinical practice because, in therapy, verbs are often trained in sentence context.

The results from this study could be explained by referring to the embodied view of cognition, which states that semantic knowledge is partly rooted in the sensorimotor system (Wilson, 2002). The neural systems involved in retrieving semantic knowledge are also involved during the perception of various sensory modalities and in the actual performance of the action. Therefore, when someone sees another person performing an action, this also causes activation in his own motor system. In the current study, when seeing video clips during the action-naming and sentence-production tasks, activation occurred in their motor system. This effect is the same for PWAs and non-language-disturbed participants. However, the PWAs have difficulties naming actions and therefore the activation in the motor system can be considered helpful in retrieving the verb from the sensorimotor system, whereas non-language-disturbed participants do not experience difficulties naming actions and therefore do not need the activation in the motor system to successfully retrieve the verb.

The results from the current study could, however, also be explained within the disembodied view of cognition. This theory states that concepts are not formed by information represented in the sensorimotor system but are symbolic and abstract, and therefore, separate from the sensorimotor system (Caramazza et al., 2014; Chatterjee, 2010; Humphreys et al., 2013; Mahon & Caramazza, 2008). Visual input leads to the retrieval of the concept of what the person was seeing. The concept is an abstract and a

symbolic representation, which is not formed in the sensorimotor system. Only when the concept is retrieved, a connection is made with relevant information from the motor system. The fact that dynamic depiction of actions leads to better scores in the current study can, according to the disembodied view of cognition, be caused by the more realistic depiction of actions in the dynamic condition than in the static condition. These concepts make it easier for PWAs to retrieve relevant information from the sensorimotor system and to name the action correctly.

As stated before, with respect to our study, neither the embodied view of cognition nor the disembodied view of cognition contradict the fact that semantic information of specific aspects of an action, such as movement, is activated while seeing an action and we assume that PWAs profit from this depiction of movement. Therefore, PWAs are more accurate in retrieving verbs in isolation and sentence context when working with dynamic material.

In our study, we considered the scores in three specific verb categories, namely arm-, leg- and face-related actions. PWAs were better in naming, especially arm-related actions in the dynamic condition as compared to the static condition. There were no significant differences found in the scores on leg- and face-related actions. These results do not agree with the hypothesis that naming leg-related actions would be more difficult in the static condition as compared to the dynamic condition. Arévalo et al. (2012) claimed that leg-related actions would be more difficult to depict in a static condition than arm- and face-related actions. Therefore, we expected that naming leg-related actions in a static condition would cause more difficulties in the naming task than naming arm- and face-related action and that this difference would diminish in the dynamic condition. However, we only found a significant difference in the arm-related actions. This shows that especially the retrieval of arm-related verbs profits from a dynamic depiction. Dynamic-depicted arm-related actions are better recognisable than static-depicted arm-related actions, as opposed to the other categories.

From the current study, it can be concluded that PWAs profit more from dynamic depiction of actions instead of static depictions when naming action verbs. The fact that dynamic depiction of actions leads to a better performance on action naming corresponds with earlier studies (d'Honinckhun & Pillon, 2008; Druks & Shallice, 2000; Fung et al., 2001). This study also provides evidence that the same effect can be found in sentence production.

This study implicates that, in clinical practice, dynamic material, rather than static material, should be used in therapy and diagnostics involving action naming and sentence production. PWAs clearly benefit from dynamic depictions. When using static material, therapists and clinical linguists should take the shortcomings of these materials into account.

The results of this study have prompted us to develop a therapy programme with dynamic material for the treatment of PWAs. We intend to perform an effect study when the programme is ready for use. Furthermore, it leads us to another research question: whether the difference between static and dynamic depictions also occurs in understanding action verbs.

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Appendix 1

Item	Frequency	Transitivity	Instrumentality	Name relation to a noun
Action naming				
To walk (lopen)	H	I	i–	–
To yawn (gapen)	H	I	i–	–
To wave (zwaaien)	H	I	i–	–
To seesaw (wippen)	H	I	i+	N+
To switch (schakelen)	H	I	i+	N–
To pinch (knijpen)	H	T	i–	–
To stroke (aaien)	H	T	i–	–
To eat (eten)	H	T	i–	–
To write (schrijven)	H	T	i+	N–
To weigh (wegen)	H	T	i+	N–
To wink (knipogen)	L	I	i–	–
To ring the bell (aanbellen)	L	I	i–	–
To rake (harken)	L	I	i+	N+
To screw (schroeven)	L	I	i+	N+
To play cards (kaarten)	L	I	i+	N+
To play checkers (dammen)	L	I	i+	N–
To blow one's nose (snuiten)	L	T	i–	–
To thread (rijgen)	L	T	i–	–
To rasp (raspen)	L	T	i+	N+
To type (typen)	L	T	i+	N–
Sentence production				
To climb (klimmen)	H	I	i–	–
To run (rennen)	H	I	i–	–
To swing (schommelen)	H	I	i+	N+
To ride a bike/to cycle (fietsen)	H	I	i+	N+
To phone (bellen)	H	I	i+	N–
To drink (drinken)	H	T	i–	–
To push (duwen)	H	T	i–	–
To fry (bakken)	H	T	i+	N–
To sew (naaien)	H	T	i+	N–
To read (lezen)	H	T	i+	N–
To fuel (tanken)	L	I	i+	N–
To salute (salueren)	L	I	i–	N–
To play chess (schaken)	L	I	i+	N–
To play soccer (voetballen)	L	I	i+	N+
To braid (vlechten)	L	T	i+	N+
To massage (masseren)	L	T	i–	–
To peel (pellen)	L	T	i–	N–
To drum (trommelen)	L	T	i+	N+
To sift (zeven)	L	T	i+	N+
To prune (snoeien)	L	T	i+	N–

H: High frequent; L: low frequent; T: transitive; I: intransitive.

Appendix 2

Item	Frequency	Transitivity	Instrumentality	Name relation to a noun
Category "arm"				
To stroke (aaien)	H	T	i-	-
To wash the dishes (afwassen)	L	I	i+	N-
To play checkers (dammen)	L	I	i+	N-
To blow-dry (föhnen)	L	T	i+	N+
To play cards (kaarten)	L	I	i+	N+
To applaud (klappen)	H	I	i-	-
To pinch (knippen)	H	T	i-	-
To scratch (krabben)	H	T	i-	-
To roll up (opstropen)	L	T	i-	-
To squeeze (persen)	H	T	i+	N+
To puzzle (puzzelen)	L	I	i+	N+
To grate (raspen)	L	T	i+	N+
To stir (roeren)	H	I	i+	N-
To play chess (schaken)	L	I	i+	N-
To tear (scheuren)	H	T	i-	-
To spread (smeren)	H	T	i-	-
To drum (trommelen)	L	I	i+	N+
To fold (vouwen)	H	T	i-	-
To shammy the windows (zemen)	L	T	i+	N+
To wave (zwaaien)	H	I	i-	-
Category "leg"				
To step down /get of (afstappen)	L	I	i-	-
To ride a bike/to cycle (fietsen)	H	I	i+	N+
To crouch (hurken)	H	I	i-	-
To board (instappen)	L	I	i-	-
To kneel (knielen)	H	I	i-	-
To crawl (kruipen)	H	I	i-	-
To walk (lopen)	H	I	i-	-
To run (rennen)	H	I	i-	-
To drive (rijden)	H	I	i+	N-
To sneak (sluipen)	H	I	i-	-
To jump (springen)	H	I	i-	-
To ride a tricycle (steppen)	L	I	i+	N+
To kick (trappen)	L	I	i-	-
To get out of the car (uitstappen)	H	I	i-	-
To play soccer (voetballen)	L	I	i+	N+
To seesaw (wippen)	H	I	i+	N+
To bicycle racing (wielrennen)	L	I	i+	N-
Category "face"				
To eat (eten)	H	T	i-	-
To whisper (fluisteren)	H	I	i-	-
To yawn (gapen)	H	I	i-	-
To gargle (gorgelen)	L	I	i-	-
To cough (hoesten)	H	I	i-	-
To interview (interviewen)	L	T	i-	-
To wink (knipogen)	L	I	i-	-
To kiss (kussen)	H	T	i-	-
To laugh (lachen)	H	I	i-	-
To lick (likken)	H	I	i-	-
To bite one's nails (nagelbijten)	L	I	i-	-
To sneeze (niezen)	L	I	i-	-
To blow up (opblazen)	L	T	i-	-
To taste (proeven)	H	T	i-	-
To shout (roepen)	H	T	i-	-
To blow one's nose (snuiten)	L	T	i-	-
To blow out (uitblazen)	L	T	i-	-
To spit out (uitspuigen)	L	T	i-	-
To choke (verslikken)	L	I	i-	-
To sing (zingen)	H	I	i-	-

H: High frequent; L: low frequent; T: transitive; I: intransitive.