The selection of distinctive features in pantomime production by people with aphasia compared to non-brain damaged people

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Abstract

Background: Aphasia can be defined as an acquired language disorder, affecting the ability to produce and comprehend spoken and written language. In many aphasic cases a semantic disorder co-occurs, which specifically affects semantic processing. Studies have shown that people with aphasia (PWA) could benefit from relying on other modalities of communication than solely speech, like for example gestures. Pantomime, the use of solely gestures in order to express something in case of complete absence of speech, can consciously be produced by PWA. The selection of distinctive features, which strongly relies on the semantic system, seems an important factor in pantomime production. This raises the question on how PWA produce pantomimes compared to non-brain damaged people (NBDP) and whether this process is affected by a semantic disorder.

Aim: The present study aimed to investigate the selection of distinctive features in pantomime production by PWA, both with and without a semantic disorder, compared to NBDP.

Method: For this study video footage of an earlier study by Van Nispen et al. (2016) was used. The existing data existed of participants performing the Boston Naming Test by pantomiming a set of 30 illustrated items. For the present study footage of 24 participants was selected from the existing dataset. We compared three groups, namely NBDP (*n=8*), PWA (*n=8*) and people with aphasia and a semantic disorder (PWA+SD; *n=8*). For each produced pantomime it was coded whether conceptual knowledge was present, which semantic information domain was used, whether a distinctive feature was pantomimed and whether the pantomime was comprehensible.

Results: Analyses showed that NBDP produced significantly more pantomimes originating from the functional and the associative/encyclopedic information domain compared to PWA and PWA+SD. Additionally, PWA+SD produced significantly less pantomimes containing a distinctive feature compared to PWA and NBDP. Moreover, the comprehensibility of the pantomimes produced by PWA+SD was rather low compared to PWA and even more so in comparison to the pantomimes produced by NBDP.

Conclusions: The main findings reveal that a semantic disorder seems to affect the selection of distinctive features. However, even though NBDP and PWA do not differ in the selection of distinctive features, the comprehensibility of the produced pantomimes by PWA is half as low compared to NBDP. Both aphasia and a semantic disorder seem to influence the use conceptual knowledge and possibly the accessibility of the functional and associative/encyclopedic semantic information domains. In relation to the clinical implications, language therapists could draw attention to the context in which pantomimes are produced and focus less on the limited execution by PWA and PWA+SD. Notifying the interlocutors to keep these two aspects in mind could enhance the communication process for all parties.

Key words: *aphasia, pantomime, semantic disorder, distinctive feature, gesture*

Preface

Before you lies the master's thesis "The selection of distinctive features in pantomime production by people with aphasia compared to non-brain damaged people", the final product of my master Communication Design. The basis for this research originally stemmed from my interest in the human brain and my amazement of the complexity of it. During a class of Psycholinguistics in the pre-master of Communication and Information Sciences a guest lecture was given by Karin van Nispen. During the lecture we discussed the effects of aphasia on the language production and comprehension process. This lecture had really sparked my interest and looking back I am very pleased that I could dedicate my thesis to this specific topic.

Reading about aphasia and witnessing the effects of it on patients made me realize the relevance of this subject, wanting to contribute to the existing literature which hopefully will lead to a better understanding of this language disorder. When exploring the theory and formulating the research question, I realized how complex the topic was and regardless of my interest, how little I knew about it. Looking back I can say that I have learned a lot and managed to achieve a level of expertise I did not expect when beginning this journey. Executing the research and reporting the findings was challenging at some points, nonetheless I have enjoyed conducting the study and I am grateful for all the knowledge and research skills I gained during the process.

In truth, I could not have completed my master's thesis and present it to you in the current form without the support of several people who I would like to thank. First of all my thesis supervisor Karin van Nispen, for her motivation to achieve the best possible result, patient guidance, sincere interest but above all the pleasant cooperation. My second reader Ruud Koolen, for taking the time and providing essential feedback to raise the bar on the quality of my thesis. Secondly my partner Kaan, for always having a word of advice and encouraging me to reach the finish line. My dear friends and family, you know who you are, for the constant interest and motivating words. My special gratitude goes out to my mother, for her unconditional support, setting the best possible example and being my inspiration every day. Lastly, I would like to dedicate this piece of work to my father.

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Introduction

From the moment we wake up, till the moment we go to sleep, the majority of the people are very frequently in contact with others. We talk with our spouses, our colleagues and friends. Think about for example asking your spouse to hand the milk or telling your colleague about your family trip last weekend. Unfortunately, these "simple" daily interactions often become problematic for people with aphasia (PWA). Aphasia is an acquired language disorder often caused by a stroke (Bastiaanse, 2010). The symptoms can differ from not being able to understand words in both spoken and written language, to the inability to produce fluent speech or finding specific words to express a thought. This impairment affects the daily lives of PWA, forcing them to make significant adjustments in their lives and reinventing the way they communicate. As the verbal component of language is often impaired, PWA might benefit from relying on other modalities of communication than solely speech in order to express themselves effectively (Cicone, Wapner, Foldi, Zurif, & Gardner, 1979; Hogrefe, Ziegler, Weidinger & Goldenberg, 2012).

PWA sometimes make use of alternative means of communication, such as gesture (Rose, 2006). When they cannot say a word (e.g:. *comb*), they could try to produce a gesture (e.g.: *pretending combing their hair*). This conscious use of gesture in case of complete absence of speech is called pantomime (McNeill, 2000). As speech is one of the most embedded communication methods, we may not consciously think about the processes involved when we speak. One aspect that possibly makes language production more effortless, is the presence of conventions. In language we have a specific mapping between word and meaning. The form and meaning of words, meet a socially constituted group standard which serves as a framework (Traxler, 2011). Think about aspects such as spelling, grammar and punctuation. This is however not the case for pantomimes, which leads to endless possibilities of how you would like to express yourself. In other words: there are no conventions applied in the meaning of pantomime (McNeill, 1992). The speaker is entirely free to produce a pantomime without any restrictions or guidelines. However, in order to communicate effectively conventions can be useful, as they minimize ambiguity and miscommunication. This raises the following question: if no conventions are applicable, how do people produce pantomimes? And more importantly: are they still comprehensible?

Despite the lack of conventions, the study of Van Nispen, van de Sandt-Koenderman, Mol and Krahmer (2014) showed some general patterns, indicating that pantomime is not entirely idiosyncratic. For example for the item "*whistle*" the majority of the participants used a handling technique (e.g.: *pretending to blow on a whistle*). This shows that the mental representations and associations (including shape, use, sound etc.) people have of certain objects have considerable overlap (Barsalou, 1999) and can be relied on in case conventions are absent. Moreover, the study of Van Nispen, van de Sandt-Koenderman, Mol and Krahmer (2015) showed that PWA use different pantomime techniques compared

to NBDP by relying less on handling and object techniques, while on the other hand relying more on shape techniques. An earlier study of Mol, Krahmer and Van de Sandt-Koenderman (2013) showed the same pattern in gesticulation techniques and linked this to the use of conceptual knowledge. Apparently, PWA rely much more on techniques that do not require conceptual knowledge (e.g.: *outlining the shape of a fork*) and much less on techniques that do require conceptual knowledge (e.g.: *pretending to use a fork*). Can this be a possible indication that PWA have difficulties to access or select conceptual knowledge?

One of the disorders that often co-occur with aphasia is a semantic disorder, which affects semantic processing, impairing the ability to make judgements with regard the meaning of words (Bastiaanse, 2010). Each word or concept can be associated with a wide range of features, which originate from different semantic information domains. These domains consist of information such as the function, sound and shape of a certain object or concept. Despite these various features from different semantic information domains, people seem to choose consciously and effectively the most obvious features in order that the receiver or listener understands what the sender is transmitting. These are so-called salient, or distinctive, features (Cree, McNorgan & McRae, 2006). A distinctive feature acts like a strong cue to the corresponding concept which rules out other possible concepts. However, are PWA, and more specifically with a semantic disorder, able to make judgements with regard to the selection of distinctive features? This question is yet not answered, however the answer could be of great value for gaining better understanding of the language disorder and provide input for clinical implications.

Despite the challenges PWA seem to experience in the communication process, the study of Van Nispen, Van de Sandt-Koenderman and Krahmer (2017) shows very promising results. In this study PWA were able to produce comprehensible pantomimes, which in some cases are even more comprehensible compared to their speech production. In terms of therapy planning, this method could hold potential benefits for PWA as speech, which is often impaired, is not involved. The study of Christopoulou and Bonvillian (1985) showed that therapy which focuses on the non-verbal aspect can be beneficial in terms of a positive attitude towards the used method, as the focus lies on what PWA are still able to do, instead on focusing on what is impaired.

Conclusively, two aspects seem to be significant in the pantomime production process: access to and selection from the semantic information domains. As pantomime could hold great potential for PWA as alternative communication method it is important to gain insight to which extent aphasia and possibly a semantic disorder affect these two aspects. Therefore, the present study aimed to answer the following research question: How do people with aphasia, both with and without a semantic disorder, differ in the selection of distinctive features when producing pantomimes, compared to non-brain damaged people?

Theoretical background

Aphasia

Hearing someone speak, understanding the content and being able to talk back seems so naturally that you may not think about this consciously when doing it. However, in order to complete this seemingly simple task, a lot of different areas in our brain are activated and have to work together. For the majority of the population the left side of the brain, the left cerebral hemisphere, is dominant for language production and comprehension (Ingram, 2007). Figure 1 illustrates the different areas in the cerebral cortex, including the language areas which are represented with a darker grey color. Whenever these are damaged, for example through trauma or as a result of a stroke, this very likely will lead to aphasia. Consequently, the ability to communicate and express yourself through spoken language would be impaired.

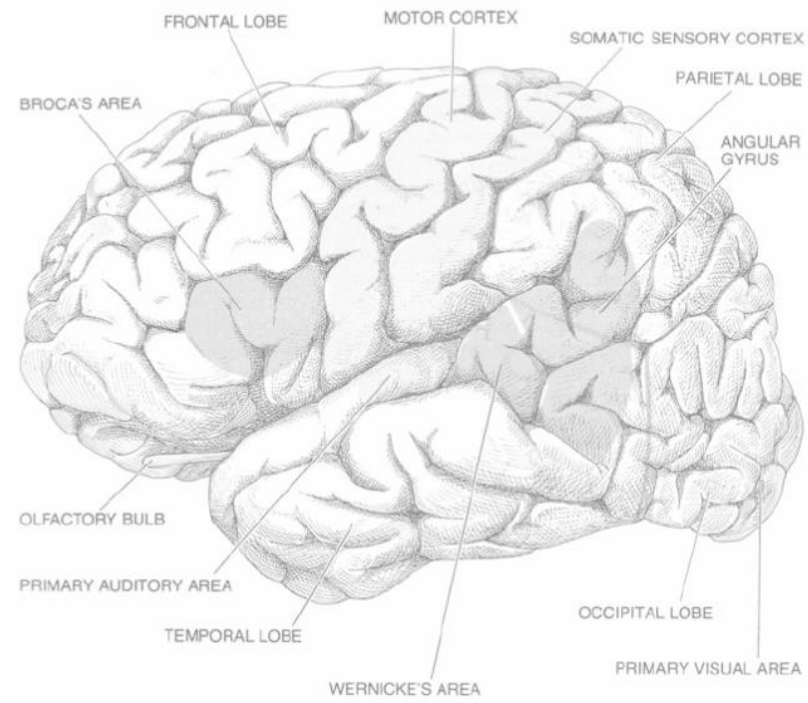

Figure 1. The cerebral cortex: the language areas and major anatomical landmarks. Reprinted from *Neurolinguistics: An introduction to spoken language processing and its disorders* (p.11), by J.C. Ingram, 2007, Cambridge University Press.

Aphasia can be defined as an acquired language disorder, affecting the ability to produce and comprehend spoken and written language. This impairment is in many cases caused by brain damage in the left

hemisphere due to a stroke (Bastiaanse, 2010). An estimated 30.000 people in the Netherlands are diagnosed with aphasia. Each year about 48.000 people suffer a stroke, of these cases approximately 20% leads to permanent aphasia (Afasie Vereniging Nederland, 2018). Something which may increase the number of PWA in the future is the fact that the population of elderly in the Netherlands has been increasing over the years. Where now approximately 25% of the population is 65 years or older, in 2035 this number will increase to 35% (Spijker & Macinnes, 2014). As a stroke is a condition which often occurs among the elderly population, this may result in a higher number of strokes in the future which eventually may lead to a higher number of cases of aphasia (Bots, Buddeke, van Dis, Vaartjes, & Visseren, 2015; Truelsen, Ekman & Boysen, 2005). In some cases partial or even full recovery of aphasia is possible. In the study of El Hachioui et al. (2013) close to 40% of the patients showed substantial signs of recovery in the first 12 weeks after a stroke. Unfortunately, the majority of post-stroke survivors will experience language difficulties for the rest of their lives (Maas et al., 2012).

PWA have very diverse symptoms and no patient is exactly the same. This may be explained by the various linguistic areas in the brain and the processes involved in language production and comprehension. Each of these areas and processes can be fully or to some degree impaired due to aphasia which evidently leads to a different manifestation of symptoms (Ellis &Young, 1996). For example, individuals suffering from aphasia may have a fairly preserved comprehension of spoken and written language, yet they may produce non-fluent speech which sometimes contain utterances of only a few syllables. Other symptoms can manifest in the form of having fluent speech which is grammatically correct, however the content may not make any sense as irrelevant or non-existing words are used (Bastiaanse, 2010; Brown, 1972).

An important fact to keep in mind is that PWA generally have their full intellectual abilities, as aphasia is a language disorder rather than a cognitive disorder. A large part of PWA suffer from an impairment in the production of the message they would like to transmit, nevertheless the message itself is well-formed in their mind and not affected in the same extent as the production of that message (Goodwin, 1995, 2000). This can lead to great frustration as PWA know what they want to say, yet are not able to do so effectively through spoken language. Therefore, having a stroke and being diagnosed with aphasia is not only a psychical adjustment, but also an emotional adjustment. Moreover, aphasia is experienced as a significant influencing factor on the quality of life as many aspects such as social participation (Cruice, Worrall, Hickson & Murison, 2003), relationships with others and level of independency are affected (Ross & Wertz, 2003). The study of Bergerse, Frøslie, Sunnerhagen and Schanke (2010) indicates that even two to five years after a stroke almost half of the participants had psychiatric problems like anxiety and depression due to the stroke. This number lies much higher compared to the general population who did not suffer a stroke. Of these participants 20% was diagnosed

with aphasia, which affects the quality of daily interactions and possibly could contribute to the described problems such as anxiety and depression.

Although speech is no longer possible, there might be other ways for PWA to communicate their message. Studies have shown that in case of PWA to still transmit the message they intended to produce, yet unable due impaired speech, other modalities of communication besides spoken language may hold great potential in order to communicate effectively (Cicone et al., 1979; Hogrefe et al,. 2012).

Gesture and pantomime

Besides speech, there are several other ways to 'send' a message. The process of communication distinguishes several basic elements: the sender, the message and the receiver. The message can be sent and received through different channels and in different forms, namely verbal or non-verbal (Oomkes, 2000). One of these non-verbal communication forms is gesture. For instance when your colleague is on the phone and you want to know if he wants a cup of coffee, you could use a gesture as you do not want to interrupt his phone call. You look at him and *pretend to drink.* Your colleague could answer with a simple *nod.* This example shows that even with no speech, both parties comprehend and produce a certain message which leads to effective communication.

Gesture is a form of nonverbal communication which includes movement of the body, in particular the hands, to express an idea or thought, which may convey information for the interlocutor (McNeill, 1992). The majority of the gestures that are produced are so called co-speech gestures, these gestures are produced unconsciously and simultaneously with speech, like for example *pointing up* when saying *"That box is in the attic"* (Kendon, 1994). McNeill (1992) distinguishes three types of co-speech gestures, namely: iconic, metaphoric and deictic. When you tell your friend you are in a hurry and *pretend to run*, this can be considered an iconic gesture as it resembles the real act of running. Metaphoric gestures refer to more abstract concepts such as *twirling your index finger closely to your head* when you want to refer to "*someone(acting) crazy*". Deictic gestures indicate the act of pointing, like for example *pointing at your leg.* Many studies have argued the significant contribution of co-speech gestures to the comprehension of language (Kelly, Barr, Church, & Lynch 1999; McNeill, 1992; Thompson & Massaro, 1994) indicating that co-speech gestures can be considered as an important and often useful component of communication. Moreover, it is assumed that both the production of speech and co-speech gestures are tightly linked to each other (McNeill, 2005). As it is not always possible for PWA to express themselves through spoken language, the expectation is that the production of co-speech gestures may also be affected. However, the gesture described in the example earlier, *pretending to drink*, is not accompanied by speech. Nonetheless, the gesture is consciously produced and compensates for the lack of speech.

In the case of complete absence of speech and the use of solely gestures in order to express something, we speak of pantomime (McNeill, 2000). The processes involved in producing pantomimes may differ from the processes involved in producing co-speech gestures (Goldin-Meadow, So, Özyürek & Mylander, 2008). This raises the question whether PWA are still able to produce pantomimes and perhaps use this method as compensation for their impaired speech. The study of Van Nispen, Van de Sandt-Koenderman, Mol and Krahmer (2016) showed that PWA are able to produce pantomimes in their communication. Moreover, a more recent study of Van Nispen, Van de Sandt-Koenderman & Krahmer (2017) revealed that the pantomimes produced by PWA were comprehensible and in some cases even more comprehensible compared to their speech production (e.g.: participants were able to produce a pantomime for the word "*palette*", however unable to produce the word while speaking).

Extensive literature on co-speech gestures is available (Dick, Goldin-Meadow, Hasson, Skipper & Small, 2009; Kelly et al., 1999; Thompson & Massaro, 1994), possibly as co-speech gestures are more frequently used compared to pantomimes. However, it remains ambiguous if the findings with regard to the production of co-speech gestures can be applied on the production of pantomime. Little is known about the pantomime production process, especially when it comes to PWA. Therefore, one of the main goals of this study is to give insight in the pantomime production process of PWA compared to NBDP and shed light on the influencing factors.

Pantomime production

Imagine playing a game of "Hints". Hints is a game where the players are not allowed to speak but they must make clear to the rest of the team which word or combination of words they are representing without mentioning it. Imagine you picked a card with the words "*umbrella*". You could *pretend opening the umbrella and holding it above your head* or *act like it's raining* or maybe *draw the shape of the umbrella in the air*. The possibilities are endless. In this case there are many different options possible for explaining a certain concept, as there are no conventions applied in the meaning of pantomime (McNeill, 1992). This in contrast to language, where we have a specific mapping between word and meaning. Although the letters and sounds for '*umbrella*' are arbitrary, its meaning is clear to speakers of the English language.

The use of conventions (e.g.: spelling, grammar, and punctuation) leads to overall agreement and consequently an overall comprehension of what is being expressed. When no conventions are applicable, which is the case in pantomime production, this means that the speaker is entirely free to produce a pantomime without any restrictions on one hand, yet no guidelines on the other hand. This leads to endless possibilities and the following question: are the pantomimes still comprehensible? The endless possibilities due the lack of conventions may lead to ambiguity, as each individual may produce a

different pantomime for a certain concept. However, the study of Van Nispen et al. (2014) showed that pantomime is not entirely idiosyncratic, as the techniques used by the participants to represent objects in pantomime were similar. For example for the item "whistle" the majority of the participants used a handling technique. This technique represents the function of the item: how or for what purpose a whistle is used (e.g.: *pretending to blow on a whistle*). This uniformity in techniques may be a explained by the similarity in mental representations of certain objects (Barsalou, 1999), which may provide a foundation for pantomime production. Barsalou (1999) argues that even though the mental representations (including shape, use, sound etc.) people have of certain objects may differ culturally, a large part probably will show considerable overlap. Regardless the lack of conventions in pantomime production, these 'default' representations people have may contribute to the comprehensibility of the message.

Another study of Van Nispen et al. (2015) showed that PWA were capable to use different techniques when producing pantomimes. However, the use of these techniques by PWA differed as a group from the techniques used by NBDP. The main difference was that PWA depended more on using shape techniques, indicating the action of outlining or molding the shape of a certain object with their hand (e.g.: *drawing the shape of a guitar with your finger in the air*). Earlier studies have speculated that gestures using shape techniques may be less complicated to use in comparison to other techniques (Cocks, Dipper, Middleton & Morgan, 2015; Cocks, Dipper, Pritchard & Morgan, 2013; Mol et al., 2013). A possible explanation is that the requirement of knowledge for the use of shape techniques is limited to the shape of a certain object, containing no conceptual knowledge. The use of other techniques often demands different semantic information domains, such as knowledge with regard to the function of a certain object and the accompanied movement and actions. Due to aphasia, the access of these semantic information domains and semantic processing in general, may also be impaired.

Semantics and aphasia

One of the key factors for effective communication is that receiver understands the content that is being produced by the sender. The idea that language can communicate meaning can be referred to as semantics. Semantics is one of the essential characteristics of language where words, signs and signals can be assigned a specific meaning in order to communicate effectively (Traxler, 2011). A distinction can be made between two important areas. First, logical semantics, responsible for associations connected to the concept, sense and reference. Second, lexical semantics, responsible for the analysis of word meanings and the grammar that makes it possible to form meaningful sentences. For example, when talking about an *apple*, the mental representation and distinctive features of that concept may occur in your mind. Things like that it is a *type of fruit that grows on a tree*, has a *round shape*, often is *colored red or green* and that it *tastes sweet*. These aspects can be assigned to logical semantics. When hearing

the sentence "*Are you eating an apple?*" and being able to interpret the meaning correctly and form a possible reaction, can be assigned to lexical semantics.

Whenever the production and comprehension of words and their meaning is impaired, we speak of a semantic disorder (Bastiaanse, 2010). A semantic disorder often co-occurs with aphasia and has many different manifestations. Dharmaperwira-Prins (2000) describes both verbal as non-verbal manifestations of a semantic disorder. In case the patient experiences difficulties assigning the correct meaning to a certain word, it is referred to as a lexical-semantic disorder (verbal). In case the patient has trouble with recognizing and naming certain objects, it is referred to as a visual-semantic disorder (non-verbal). The present study focused on the latter. The presence and severity of the semantic disorder was established through the Semantic Association Task (Visch-Brink, 2005) where participants had to match pictures to each other. For example when a picture of a *tie* was shown, participants had to judge whether it belonged to a picture of a *hat* or a picture of a *palm tree*. This shows that a semantic disorder is far more complex. If you suffer from a semantic disorder you may not be able to speak and understand language well. However, the reverse does not mean that you automatically have a semantic disorder.

The use of certain pantomime techniques by PWA seems to be related to a semantic disorder (Hogrefe et al., 2012). It seems that PWA have difficulties with accessing different semantic information domains and therefore may rely more heavily on the domains that are easy accessible. Carmazza and Shelton (1998) and Warrington and Shallice (1984) suggest there are four types of semantic information domains, namely: perceptual information (*a dog has four legs*), functional information (*a dog is used for hunting*), associative information (*a dog chases cats*) and encyclopedic information (*a dog is a part of many breeds*). For example when the access to the semantic information domain with regard to the function of a comb (e.g.: *pretending to comb hair)* is impaired, this may force the speaker to choose a pantomime technique that does not involve this information. Consequently, the speaker will choose information from another domain which is accessible, like for example the perceptual domain (e.g.: *outlining the shape of a comb).*

However, despite the possible impairment in the accessibility of semantic information domains, it seems that PWA are able to transfer meaning through pantomime, which they are not able to through spoken language. In the study of Van Nispen et al. (2017) it is very promising to see that PWA are able to produce comprehensible pantomimes, which in some cases are even more comprehensible compared to their speech production. Certain concepts could be pantomimed very clearly, transmitting essential semantic information, which could not be produced through spoken language. This again indicates the potential of pantomime as a way to communicate when speech is impaired.

Distinctive features

Possession or accessibility of certain semantic information is one of the important factors in the communication process. However, the selection of specific semantic information also seems to play an important role. In the example of the *apple,* many features may come to mind such as that it is a *type of fruit* that *grows on a tree*, has a *round shape*, often is *colored red or green* and that it *tastes sweet*. All these features vary in meaning and association, yet are somehow related to the concept and can be assigned to different semantic information domains. However, despite the wide range of features that come to mind when hearing or reading a certain word, people seem to choose consciously and effectively the most obvious features in order for the receiver or listener to understand what the sender is transmitting. These are so-called salient, or distinctive, features. Cree, McNorgan & McRae (2006) describe distinctive features as "those that occur in only one or a very few concepts and thus allow people to discriminate among similar concepts" (p.2).

Each word or concept can be associated with a wide range of features, which originate from different semantic information domains. These domains consist for example of information with regard the function, sound and shape of a certain object or concept. Despite this great variety in features which may come to mind, people seem to first list the distinctive features before moving on to other features (McRae, Cree, Seidenberg, & McNorgan, 2005). The study of Barsalou (1999) argues that even though what we consider to be distinctive features may differ, through for example cultural differences, overall we can rely on the mental representations we have of certain objects as they seem to be alike among the large population. It is possible that throughout the years, this information has obtained a privileged status when it comes to conceptual representations in our mind (Cree & McRae, 2003; McRae, Cree, Cho & McNorgan, 2005). To give an example, when asked to list the first things that come to mind when hearing or reading the word *tiger,* features such as *having black and orange stripes* or *that it's a big feline* may be listed first. Consequently, due to this tendency other more general features that apply onto a broader range of conceptual representations (e.g. *it's an animal* or *it has a tail),* may be less evidently to be listed first. This natural tendency may be considered as a strength as it appears that these general, broad applicable, features play only a small role in object or concept identification (McRae et al., 2005). Thus in other words: a distinctive feature acts like a strong cue to the corresponding concept which rules out other possible concepts.

One of the most acknowledged studies with regard to distinctive features is from McRae et al. (2005), who developed a large dataset and determined distinctive features for 541 living and non-living objects which were assigned to different semantic groups. One important distinction which was made in this study was whether the feature contained conceptual knowledge or not. For example for the item "*helicopter*" one of the distinctive features is that *is has propellers.* This features contains no conceptual

knowledge as it can be established by solely the appearance of the object, the propellers are visually noticeable. However, another distinctive feature is that *it can be used for flying.* This feature does contain conceptual knowledge as more information than solely its appearance is needed in order to describe it. A study of Mol et al. (2013) showed that PWA mainly use gesture techniques which do not require conceptual knowledge. Expressing conceptual knowledge in feature selection could be linked to access to and selection from certain semantic information domains, which may be problematic for PWA.

Lastly, an interesting factor in the selection of features in verbal production, is the complexity of the knowledge that the features contain. The study of Barsalou, Sloman & Chaigneau (2005) argues that color features (*the apple is red)* or parts *(the airplane has wings)* appear to be relatively simple to produce, opposed to functional features *(a pen is used for writing)*. Function features likely represent a broad range of situational or functional knowledge with regard to the different conditions under which a pen is used, making them more difficult to choose from and express. Opposed to color or part features, which are visually noticeable and perhaps easier to mentally represent. However, little is known about how this would manifest in case of pantomime production, as color features (*the apple is red*) are very difficult, if not impossible, to produce. Moreover, to our knowledge the effect of aphasia or a semantic disorder on the selection of distinctive features in pantomime production, has not yet been studied.

Present study

PWA can possibly benefit from other modalities of communication like pantomime in order to communicate effectively, considering their speech abilities are often impaired. However, little is known about the pantomime production process, especially in case of aphasia. The study of Van Nispen et al. (2015) shed light on the pantomime techniques used by PWA opposed to NBDP and discovered a difference among the groups. However, the cause of this difference has yet not been investigated. Therefore, the present study investigated whether this could possibly be explained by an impairment in the distinctive feature selection.

The comparison was made between people with aphasia (PWA, n=8), people with aphasia and a semantic disorder (PWA+ SD, n=8) and non-brain damaged people (NBDP, n=8). Existing videotaped data from the study of Van Nispen et al. (2016) which focused on pantomime techniques, was used for the present study. In the original study the participants had to perform the Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983) by explaining what was illustrated on the pictures without using their speech, in other words: by producing pantomimes. The present study developed a coding scheme that coded the presence of conceptual knowledge, access of semantic information domains, depiction of distinctive features and the comprehensibility of pantomimes for each pantomime produced by each participant. This exploratory study aimed to answer the following research question: how do PWA, both

with and without a semantic disorder, differ in the selection of distinctive features in pantomime production compared to NBDP? We aimed to gain new insights and contribute to a better understanding of the language impairment. Moreover, findings could inform clinical practice on the different processes of pantomime production PWA struggle with and provide advice for future therapy planning.

Method

Existing dataset and experiment procedure

The present study used an existing dataset which was compiled for the dissertation study *"Talking with your hands"* by Van Nispen et al. (2016). The participants (PWA: n = 38, NBDP: n = 20) were aware of, and agreed on, the fact that the experiment would be videotaped. The experiment took place in a quiet room where the participant sat across the researcher as the camera was placed diagonally behind the researcher. This resulted in video footage of mainly the side front view of the participant and partly the researcher, as can be seen in Figure 2.

Figure 2. Screenshot of the videotaped material, illustrating the setting of the experiment.

As the procedure was fully explained to the participant, the execution of the test started. The participants had a folder on the table in front of them which consisted of 30 images of objects from the Boston Naming Test (Kaplan et al., 1983) that were individually illustrated per page. The list of objects can be seen in Table 1 and contained both living (animal) as non-living objects (tool). The researcher was not able to see the illustrations as the folder was shielded. The participants were asked to make clear to the researcher what item was illustrated on the image in front of them, without using their speech. The participants could produce multiple pantomimes per item. The researcher did not respond whether the pantomime was clear to her or not, there was no interaction with regard to the comprehensibility of the

produced pantomimes. After the participant was convinced that the produced pantomime was sufficient, the researcher turned around a card which illustrated three items and picked out the item which she thought was pantomimed by the participant. The chosen item was however not communicated to the participant, it was only noted by the researcher. After this the participant could proceed to the next image.

Table 1

Items used from the Boston Naming Test (Kaplan et al., 1983) numbered in order as executed in the experiment.

Item	Item	Item	Item	Item
1 bed	7 octopus	13 volcano	19 escalator	25 noose
2 pencil	8 clothes hanger	14 dart arrow	20 hammock	26 drop shutter
3 whistle	9 camel	15 beaver	21 pelican	27 scroll
4 comb	10 pretzel	16 rhino	22 pyramid	28 sphinx
5 saw	11 (tennis) racket	17 igloo	23 unicorn	29 palette
6 helicopter	12 snail	18 domino stones	24 funnel	30 abacus

Participants

The present study compared three groups of participants, namely people with aphasia *(*PWA, *n = 8*), non-brain damaged people (NBDP, *n = 8*) and people with aphasia and a semantic disorder (PWA+SD, *n = 8)*. An overview of the participants from the PWA and PWA+SD group and their linguistic profile are presented in Table 2. The Akense Aphasia Test (Graetz, de Bleser & Wilmes, 1991) was used in the original study to establish the presence of aphasia in these participants. Possible influencing factors such as a semantic disorder and the severity of aphasia are also listed in the table. Additionally, in yhe original study the presence and severity of the semantic disorder was determined by the Semantic Association Test (Visch-Brink, Stronks & Denes, 2005). In case a participant had a score which was lower than 17 it could be assigned as a severe semantic disorder. In case the score was between 17 and 23 this could be assigned as a moderate semantic disorder. As the test results are not applicable for the NBDP group the details are not included in the table. Four women aged between 46 and 55 (M = 51.00, SD = 3.25), and four men aged between 53 and 65 (M = 59.50, SD = 3.25) represented the NBDP group.

Table 2

*Participant details and scores for tests used to assess semantic processing and aphasia severity. * = Semantic disorder (score range 0-30, cut-off score 23), ** = Aphasia severity (score range 50-0, cut-off score 23). The participant ID numbers correspond with the participant ID number in the dissertation study by Van Nispen et al. (2016).*

ID	Group	Age	Gender	SD*	AS**
A03	PWA	54	Male	28	33
A05	PWA	50	Male	29	36
A06	PWA	59	Male	25	20
A07	PWA	58	Female	28	37
A08	PWA	63	Male	28	46
A012	PWA	60	Male	20	48
A014	PWA	57	Female	26	20
A017	PWA	50	Male	28	42
A25	PWA+SD	60	Female	18	48
A28	PWA+SD	56	Female	14	50
A30	PWA+SD	50	Female	19	44
A31	PWA+SD	67	Male	22	44
A33	PWA+SD	68	Male	23	2
A34	PWA+SD	35	Female	19	42
A36	PWA+SD	73	Female	6	49
A37	PWA+SD	71	Male	8	50

Coding

The present study used the program ELAN (Wittenburg, Brugman, Klassmann & Sloetjes, 2006) to code the produced pantomimes. This specific program enables the user to assign certain codes to specific fragments of video material, which in this case gave the opportunity to code each pantomime per item very accurately. To determine the differences between the three groups with regard to the selection of distinctive features in pantomime production, a coding scheme was developed to analyze the data. Per pantomime the following aspects were coded: presence of conceptual knowledge, use of semantic

information domains, selection of distinctive features and level of comprehensibility. These aspects are discussed in the following section, the final and extensive codebook can be found in the appendix.

Conceptual information

For each pantomime per participant it was assessed whether conceptual knowledge was needed in order to produce the pantomime, based on the study of McRae et al. (2005). If the information which was used to produce the pantomime could be derived from the image, no conceptual information was needed. For example the item "*saw*" it is possible to pantomime *the long rectangular shape of the item*. This information can be derived from the image. However, it is also possible to pantomime this item by *pretending to use the saw*. This information could not be derived from the image, which indicates that conceptual knowledge was needed in order to produce the pantomime.

Semantic information domain

Based on the studies of Carmazza and Shelton (1998) and Warrington and Shallice (1984) we distinguished three semantic information domains, namely: perceptual information, functional information and associative/encyclopedic information. Originally, the associative and encyclopedic information domain were described as two separate domains. However, as the two domains show a huge overlap it was decided to combine the two categories into one. For example for the item "*igloo*" many participants *pretended being cold*. This could be assigned to the category of associative information as igloo's are made of ice blocks and when you are in one, you experience cold. However, it could also be assigned to the encyclopedic information category, as an igloo is something you usually only find in certain areas of the world where the temperatures are low. For each pantomime per participant it was coded to which of the three categories (perceptual information, functional information or associative/encyclopedic information) it could be assigned to.

Distinctive features

We first based ourselves on the study of McRae et al. (2005), which created a large dataset of distinctive features for 541 living and non-living objects. From this set of items, 11 corresponded with the 30 items which were used in this study. However, this existing dataset was compiled based on non-brain damaged people and focused on a listing task. It is ambiguous whether the norms from this dataset could apply on pantomime production and moreover, in combination with aphasia and a semantic disorder. Additionally, the majority of the features were not useful for a pantomime task as many distinctive features were impossible to produce. For example colors (e.g.: *"is green"*) are not possible to pantomime, yet are considered as a distinctive feature. Therefore, the present study compiled a small dataset and established

distinctive features for each item based on the pantomime productions of the NBDP group. First, for each pantomime produced by the NBDP group a clear description was coded. Second, per item we counted how much times the same pantomime was produced (e.g.: *rotating propellers* for the item *"helicopter"*). Third, if five or more participants produced that same pantomime for one specific item, it was noted as a distinctive feature. The full list of all items and the corresponding distinctive features are illustrated in Table 4 of the appendix. Thus, for each pantomime produced by the participants of all three groups it was coded if a distinctive feature was expressed in the pantomime production or not.

Comprehensibility

Earlier research has revealed that pantomimes produced by PWA are less comprehensible than the pantomimes produced by NBDP, yet they transmit essential information which PWA are not able to produce through speech (Van Nispen et al., 2014, 2016). As gesture is also a part of language, it may be the case that this modality is also impaired due to aphasia whereas the execution of pantomimes may be influenced. So even though a pantomime may not be executed precisely, which could be influenced by physical limitations of aphasia, this does not mean that the feature that the participants were trying to pantomime are not related to the item. Therefore, based on the pantomimes produced by the NBDP group we added descriptions to the distinctive feature pantomimes, which can serve as a frame of reference. The descriptions can be found in Table 4 of the appendix. If a produced pantomime corresponded with the description, the comprehensibility could be coded as "*high*". In case the produced pantomime extremely diverged from the description, the comprehensibility could be coded as "*low*". Knowing the context of the pantomime, the task was to look very closely and establish what the participant intended to pantomime within that context, rather than to only judge the pantomime based on the execution. That is why even though the codebook was followed precisely, it was also kept in mind that the goal of this study was the depiction of distinctive features in pantomime production. Keeping this in mind every aspect was coded per pantomime and per participant, where lastly it was assessed whether the comprehensibility of the pantomime was high or low based on the execution.

Results

In order to answer the main question of this study, how aphasia and a semantic disorder affect the selection of distinctive feature selection in pantomime production, the collected data was analyzed. The results of the coded aspects which are discussed in the method will be reported per aspect in this chapter.

Each participant had to pantomime 30 items, with the possibility of producing several pantomimes for one item. In total 1117 pantomimes were produced by the 24 participants. The missing items, due to poor footage quality or visibility making it unable to code correctly, were not further

included in the analysis. Furthermore, as this study was interested in whether and which type distinctive features were selected in pantomime production within one item and not how many times, all repeated pantomimes were also excluded from the data. This resulted in a final dataset of 995 coded pantomimes, with an average of 41.46 pantomimes per participant and 1.38 pantomimes per item. A general overview with regard to the total number of pantomimes produced per group and the average number of pantomimes produced per item, can be seen in Table 3.

Table 3

Total number of pantomimes produced and the average number of pantomimes per item, per group.

	PWA		**PWA+SD**		**NBDP**	
	M	***SD***	***M***	***SD***	***M***	***SD***
Total number of pantomimes	40.13	10.45	32.38	11.30	51.88	11.68
Average number of pantomimes per item	1.34	0.35	1.08	0.38	1.73	0.39

Conceptual knowledge

Using a one-way ANOVA we first tested if the pantomimes produced by the three groups differed in expressing conceptual knowledge. Figure 3 illustrates the presence of conceptual knowledge during pantomime production per group in percentages.

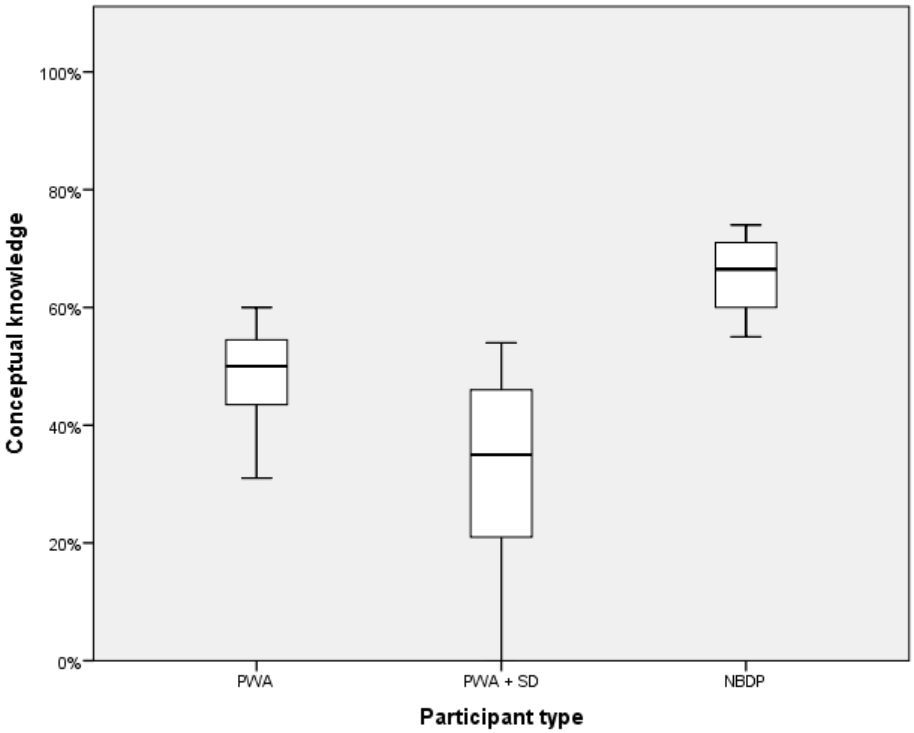

Figure 3. Presence of conceptual knowledge during pantomime production per group in percentages.

The assumption of homogeneity of variances was met as Levene's test was not significant: $F(2, 21) = 2.89$, $p = .078$. The groups differed significantly in their use of conceptual knowledge as determined by one-way ANOVA ($F(2,21) = 14.45$, $p < .001$). A Tukey post-hoc test revealed that all groups differed significantly from each other. NBDP produced the most pantomimes in which conceptual knowledge was present ($M = 65.50\%$, $SD = 6.78\%$, $p < .001$), followed by PWA ($M = 48.38\%$, $SD = 9.27\%$, $p = .030$). PWA+SD produced the least amount of pantomimes which expressed conceptual knowledge ($M = 32.25\%$, $SD = 18.09\%$, $p = .042$).

Choice of semantic information domain

Secondly, we tested whether the groups differed in the type of semantic information they conveyed: functional, perceptual and associative/encyclopedic by performing separate analyses per domain. Figure 4 illustrates the proportion of the choice of semantic information domain in pantomime production per group in percentages.

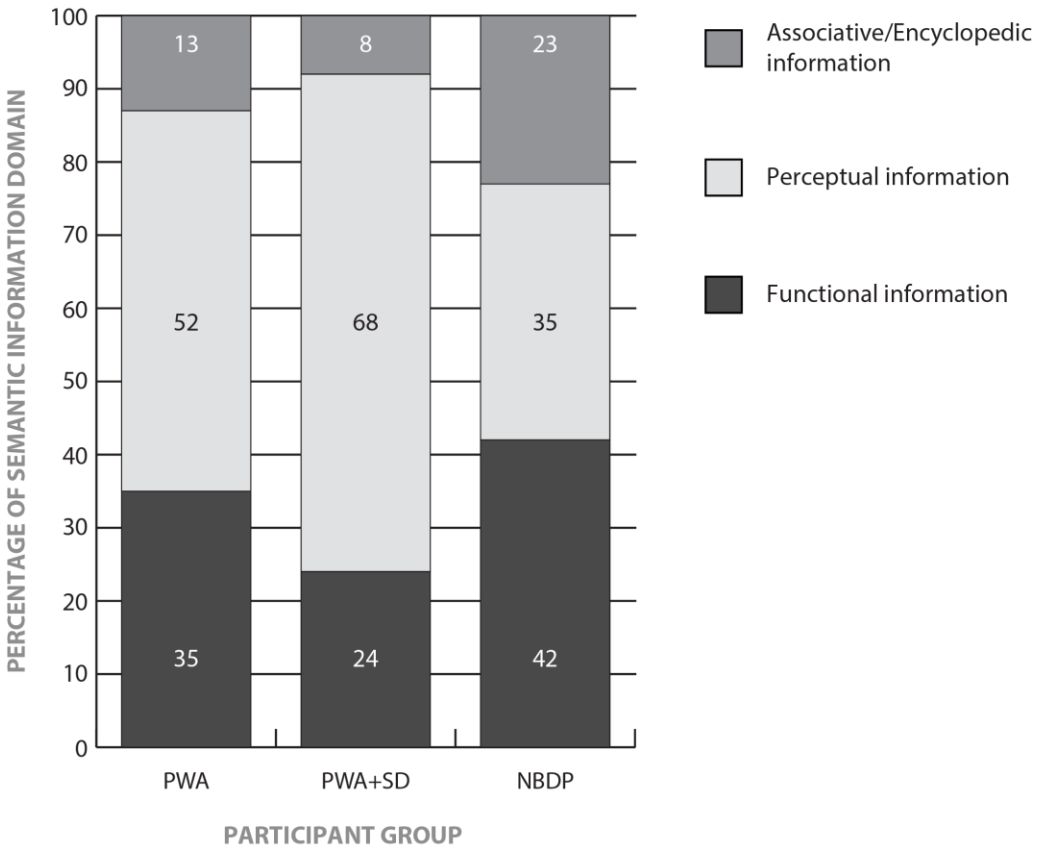

Figure 4. Proportion of the choice of semantic information domain in pantomime production per group in percentages.

For the functional information domain the assumption of homogeneity of variances was not met as Levene's test was significant: $F(2, 21) = 5.82$, $p = .010$. For this reason the Welch statistic is reported. The one-way ANOVA showed a significant effect for the use of functional information in pantomime production (*Welch's* $F(2, 11.79) = 5.90$, $p = .017$). A Games Howell post hoc test revealed that NBDP ($M = 42.25\%$, $SD = 6.78\%$) differed significantly from PWA ($M = 35.00\%$, $SD = 10.14\%$, $p = .003$) and PWA + SD ($M = 24.13\%$, $SD = 14.93\%$, $p = .002$). There was no statistically significant difference between PWA and PWA+SD ($p = .109$).

With regard to the second semantic information domain, perceptual information, the assumption of homogeneity of variances was met as Levene's test was not significant: $F(2, 21) = 36.24$, $p = .060$. All groups differed significantly from each other in their use of the perceptual information domain during pantomime production, as confirmed by the one-way ANOVA ($F(2,21) = 14.45$, $p = < .001$). A Tukey post-hoc test revealed that all groups differed significantly from each other. PWA+SD produced the most pantomimes which could be assigned to the perceptual information domain ($M = 68.38\%$, $SD = 18.45$, $p < .001$), followed by PWA ($M = 52.00\%$, $SD = 9.43\%$, $p = .033$). NBDP produced the least amount of

pantomimes which contained information from the perceptual information domain (*M* = 35.00%, *SD* = 6.19%, *p* = .040).

For the third semantic information domain, associative/encyclopedic information, the assumption of homogeneity of variances was met as Levene's test was not significant: $F(2, 21) = 1.71$, $p = .205$. There was a statistically significant difference between the groups in pantomime production related to the associative/encyclopedic domain, as determined by one-way ANOVA ($F(2,21) = 11.69$, $p < .001$). A Tukey post-hoc test revealed that NBDP (*M* = 22.75%, *SD* = 6.30%) differed significantly from PWA (*M* = 13.00%, *SD* = 5.01%, *p* = .016) and PWA+SD (*M* = 7.50%, *SD* = 7.60%, *p* < .001). There was no statistically significant difference between PWA and PWA + SD (*p* = .221).

Selection of distinctive features

For each of the 30 items and per participant it was assessed whether a distinctive feature was expressed or not. The maximum number of possible distinctive features was 42, a total list of the established distinctive features for this study can be seen in Table 4 in the appendix. Figure 5 illustrates the distribution of the selection of distinctive features between the three groups in percentages.

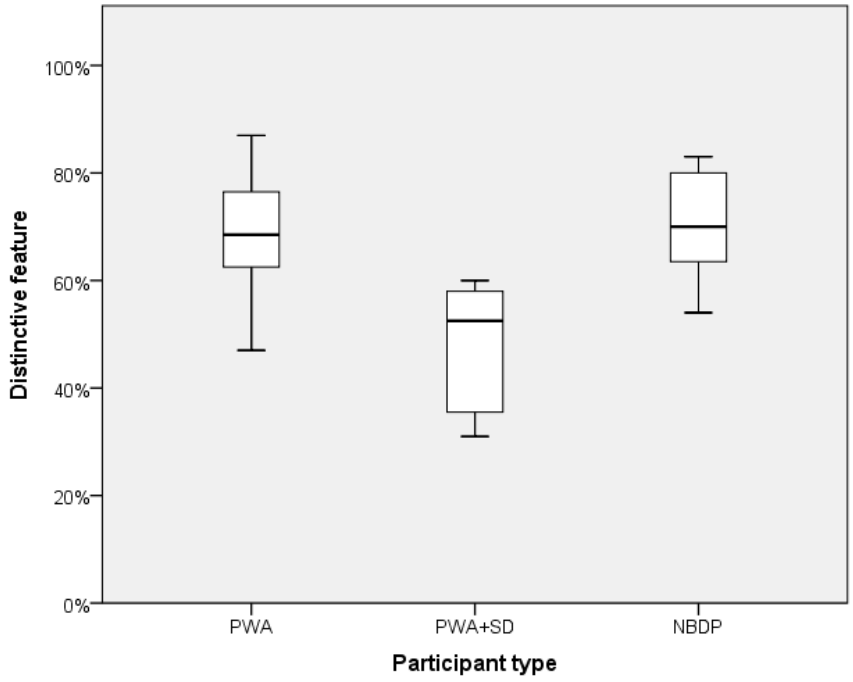

Figure 5. Presence of distinctive features during pantomime production per group in percentages.

The assumption of homogeneity of variances was met as Levene's test was not significant: $F(2, 21) = 0.21$, $p = .816$. There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,27) = 9.44$, $p = .001$). A Tukey post hoc test revealed the depiction of distinctive features was statistically significantly lower for PWA+SD ($M = 47.88\%$, $SD = 11.91\%$) compared to PWA (68.63%, $SD = 12.39\%$, $p = .005$) and NBDP ($M = 70.50\%$, $SD = 10.28$, $p = .002$). There was no statistically significant difference between PWA and NBDP ($p = .944$).

Comprehensibility

The level of comprehensibility, high or low, was assessed for each pantomime and every participant. Figure 6 illustrates the distribution of pantomimes with a high comprehensibility between the three groups in percentages.

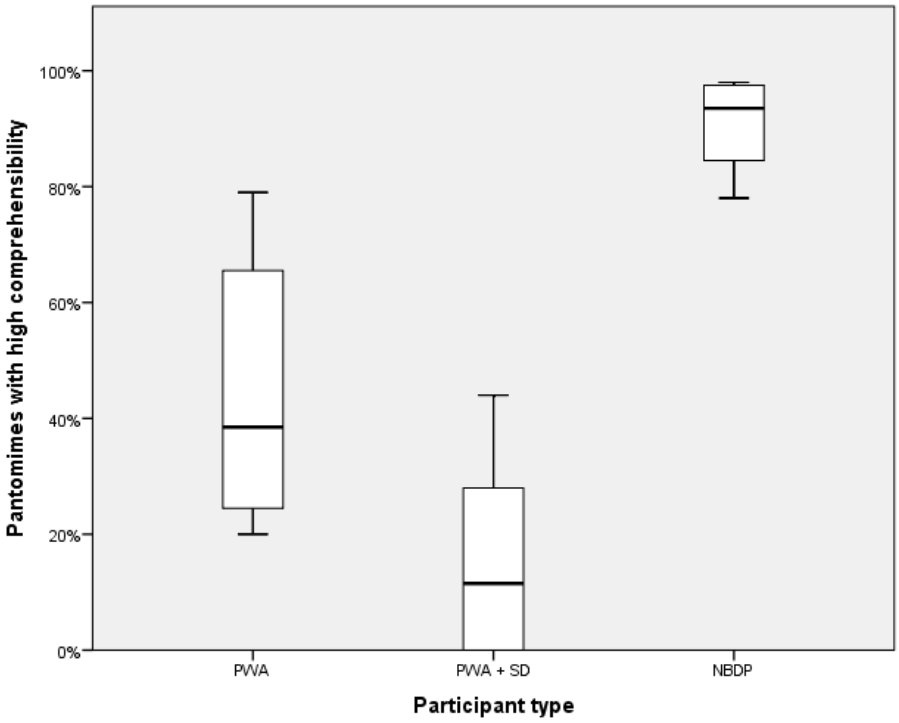

Figure 6. Distribution of pantomimes with a high comprehensibility between the three groups in percentages.

The assumption of homogeneity of variances was not met. Levene's test was significant: $F(2, 21) = 5.36$, $p = .013$. For this reason the Welch statistic will be reported. The one-way ANOVA showed a significant effect on comprehensibility, *Welch's* $F(2, 11.59) = 67.15$, $p = < .001$. A Games Howell post hoc test revealed that all groups differed significantly from each other. PWA + SD produced the least number of comprehensible pantomimes ($M = 15.38\%$, $SD = 17.42\%$, $p < .001$,), followed by PWA ($M = 44.50\%$, $SD = 22.67\%$, $p = .001$). NBDP produced the highest number of comprehensible pantomimes ($M = 90.88\%$, $SD = 7.72\%$, $p = .032$).

Discussion

This study aimed to reveal the similarities and differences with regard to the use of conceptual knowledge, accessibility of semantic information domains, depiction of distinctive feature and level of comprehensibility in pantomime production by people with aphasia (PWA), people with aphasia and a semantic disorder (PWA+SD) and non-brain damaged people (NBDP). The main findings and accompanied possible influencing factors will be discussed in this section. Lastly, the clinical implications that could be derived from the findings will be discussed.

First, an important finding is that all three groups were able to produce pantomimes that contained conceptual knowledge. However, the three groups differed from each other, namely: NBDP produced the highest number of pantomimes containing conceptual knowledge, followed by PWA, whereas PWA+SD produced the lowest number of pantomimes containing conceptual knowledge. This seems to show that aphasia affects the use of conceptual knowledge in pantomime production.

Second, we found that NBDP and PWA produced pantomimes with semantic information from all three domains tested in this study (functional, perceptual and associative/encyclopedic). PWA produce significantly less pantomimes which depict the functional information domain in comparison to NBDP. There was no difference between PWA and PWA+SD. Therefore, aphasia in general rather than specifically a semantic disorder affects the use and possibly the accessibility of the functional semantic information domain during pantomime production. A similar pattern is seen for the perceptual information domain. The findings indicate a difference between all groups, where PWA produce a higher number of pantomimes containing perceptual knowledge compared to NBDP. However, PWA+SD show the opposite pattern and produce the highest number of pantomimes containing perceptual information. The associative/encyclopedic information domain was least depicted in pantomime production compared to the other two domains by all groups. NBDP produced significantly more pantomimes containing associative/encyclopedic information compared to PWA and PWA+SD. Similar to the findings for the functional information domain, aphasia in general seems to affect the use of this specific information domain in pantomime production, rather than a semantic disorder.

Third, in contrast to the findings with regard to the presence of conceptual knowledge and depiction of semantic information domains, we found that PWA+SD differ in the selection of distinctive features in pantomime production from PWA and NBDP. There was no statistical difference between PWA and NBDP in depicting the distinctive features. This seems to indicate that semantic knowledge is needed in order to depict the salient feature in pantomime production.

Fourth, the level of comprehensibility of the pantomimes produced by all three groups differed significantly from each other. The greatest majority of the pantomimes produced by NBDP were highly comprehensible, followed by PWA, whereas PWA+SD produced a significant smaller number of pantomimes which could be considered comprehensible. This last finding indicates that both aphasia and a semantic disorder affect the comprehensibility in pantomime production. The findings described above offer input for further discussion, interpretation and possible future research suggestions.

Interpreting the previous findings it is important to keep in mind that many aspects that are involved in pantomime production are most likely closely intertwined with each other. Language production is one of the many processes that takes place in the human brain. Therefore, if other processes such as cognition or motor skills are also impaired this may impact on the language production. To increase the feasibility of this study, it was decided to investigate two aspects that seem to be significant in the pantomime production process. First, we assume that one needs to possess knowledge about a specific concept in order to pantomime it. Second, we believe that the selection of distinctive features plays an important role. Moreover, this is one of the first studies investigating the distinctive feature selection in pantomime production of both aphasic as non-brain damaged people. Therefore, based on the available literature these two aspects served as a starting point for exploring this specific topic.

The first aspect, possession of knowledge, can be linked to the findings with regard to the use of conceptual knowledge in pantomime production. We found out that both PWA and PWA+SD produce less pantomimes containing conceptual knowledge compared to NBDP. A possible explanation is that conceptual knowledge may be less accessible for aphasic patients than for NBDP. Conceptual knowledge covers every aspect that can be derived from a concept other than aspects which can be linked to the appearance (e.g.: conceptual knowledge for the item *apple* may carry the feature *edible*, non-conceptual knowledge may include a feature such as *is round*). Aphasic patients may not be able to depict this specific conceptual knowledge when producing pantomimes and rely heavily on more elementary, non-conceptual, knowledge of a certain item. The diversity that conceptual knowledge holds may be of great essence in contributing to a higher comprehension of what is pantomimed. Deriving less from this domain may limit the possibilities one has in the pantomime production, which eventually may lead to lower comprehensibility. This interpretation may be linked to the study of Van Mol et al. (2013) where they reveal that the pantomimes of aphasic patients are less informative compared to the control group

(NBDP). Moreover, conceptual knowledge is strongly connected to different semantic information domains. In this study all three groups had the ability to access and derive information from the functional-, perceptual- and associative/encyclopedic information domain. However, PWA and PWA+SD used less functional and associative/encyclopedic information domains during pantomime production compared to NBDP. These two information domains described by Carmazza and Shelton (1998) and Warrington and Shallice (1984) mainly consist of conceptual knowledge (e.g.: features like *using a comb* or *a volcano erupting*). These domains may be considered as more complex to access, compared to the perceptual information domain which consists of non-conceptual knowledge. However, another possible explanation may lie in the construction of the experiment. As participants were asked to pantomime an item from a picture, accessing the perceptual information domain may be more effortless which results in producing a pantomime that is for example based on the shape of an item rather than other features like the function or association. This interpretation is in line with the study of Van Nispen et al. (2015) which has revealed that PWA use different pantomime techniques than NBDP by relying less on handling and object techniques, while on the other hand relying more on shape techniques which origin from the perceptual information domain.

In this specific study, the depiction of distinctive features in pantomime production is considered a key factor in effective communication. The findings reveal that a semantic disorder seems to affect the depiction of distinctive feature in pantomime production. However, PWA without a semantic disorder do not differ in the selection of distinctive features compared to NBDP. In combination with the findings with regard to the comprehensibility of the produced pantomimes, this results in an interesting outcome. The pantomimes produced by NBDP scored high on comprehensibility (90.88%), while the pantomimes produced by PWA scored half as low (44.50%). These two findings combined may indicate that even though PWA and NBDP do not differ in de depiction of distinctive features in pantomime production, the low comprehensibility of the pantomimes produced by PWA may negatively affect the communication process. As mentioned before, an important fact to keep in mind is that PWA generally have their full intellectual abilities, as aphasia is a language disorder rather than a cognitive disorder. A large part of PWA suffer from an impairment in the production of the message they would like to transmit, nevertheless the message itself is well-formed in their mind and not affected in the same extent as the production of that message (Goodwin, 1995, 2000). This may also apply for pantomime production as showed by the findings. PWA may have a well-formed message and depict the distinctive features, yet not able to produce the pantomimes in a manner that is highly comprehensible.

One aspect that may be of great influence on the execution on pantomimes is apraxia. Apraxia can be defined as an impairment in motor planning, which often co-occurs with aphasia (Goodglass & Kaplan, 1963). The individuals who suffer from apraxia comprehend the instruction of the task to for

example depict a pantomime, yet are not able to motorically execute this task correctly. However, correct execution can occur in spontaneous movement when not consciously attempting to perform the action (e.g.: scratching the nose when it itches, however not being able to bring the hand to the nose when instructed). The study of Hogrefe et al. (2012) showed that the participants who suffered from apraxia used a wide range of different hand movements, trying to convey the information they had in mind. Nevertheless, despite this wide range of hand gestures the efficiency of their communication was poor as these individuals were not able to select the relevant and corresponding distinctive features from the semantic representation. Therefore, taking apraxia into consideration as a influencing factor would be of great value for future research.

This study has provided numerous interesting findings, however there is an important footnote to take into consideration with the regard to the participants and the construction of the experiment. As three groups were studied, the selection of and the distinction between groups was made as clear as possible based on their linguistic profile. Nevertheless, it is important to state that considering the unique disorder that is being studied, it is difficult to create complete homogeneous groups. Individual aspects such as age, gender and educational level may all be of influence on the outcome of the study. Moreover, as mentioned before, PWA have very diverse symptoms and no patient is exactly the same. Where some individuals suffering from aphasia may have a fairly preserved comprehension of spoken and written language, others may produce non-fluent speech which sometimes contain utterances of only a few syllables. This is illustrated by the large differences which can be seen in the standard deviation between participants in this specific study. Moreover, studies around PWA often involve other parties and their cooperation such as rehabilitation centers, hospitals and medical staff. Therefore the sample size is often small which makes it challenging to generalize the outcomes onto a large population. Future research could consider a larger sample with specific demographic and linguistic criteria, to rule out as many influencing factors as possible and raise the level of homogeneity. This increases the probability of being able to make assumptions that apply for a larger population. As mentioned earlier, level of apraxia could be a valuable addition to the selection criteria of possible participant groups.

Furthermore, the type of items used in the pantomime task could be considered of influence on the findings, as the set contains items that are unlikely to be used in daily conversation (e.g.: sphinx and igloo). Even though linguistically this test is designed from high-frequent (e.g.: pencil) words to low-frequent words (e.g.: palette), it is ambiguous whether this is the best design to apply on pantomime production. Having a language impairment and possibly lower accessibility of certain semantic domains, expressing concepts that you are not highly familiar with or do not come across often, may be more difficult compared to concepts that you hear, use or see on a daily basis. For future research it could be considered adjusting the experiment to a more natural setting, where is asked to pantomime common

everyday items. Possibly, a conversational partner could be present which can lead the conversation in a natural manner and interact with the participant, as is often the case in real life. Moreover, the Boston Naming Test (Kaplan et al.,1983) consists of solely nouns which may be limited and not represent a natural setting. Pantomiming an action or event demands different knowledge than pantomiming an object and may lead to different outcomes. The study of Dharmaperwira-Prins (2000) showed that PWA+SD experience difficulties in naming and recognizing objects, however little is known about naming or pantomiming and action or event. Therefore, incorporating verbs could be an interesting addition for future research. The Kissing and Dancing Test (Bak & Hodges, 2003) may be considered as an option to test conceptual knowledge with regard to verbs and provide new insights.

Additionally, establishing a dataset of distinctive features in pantomime production would be of great contribute in this field of research which can serve as a frame of reference. The only established dataset which can be considered useful with regard to distinctive features is developed by McRae et al. (2005). However, this study focused on speech production and not all features are useful for a pantomime task as some of them are impossible to produce. For example colors (e.g.: "*is green"*) are not possible to pantomime, yet are considered as a distinctive feature. Due to the absence of a dataset of distinctive features for pantomime production, the current study established distinctive features based on the pantomimes of the NBDP group. The pantomimes produced by NBDP were considered as default whenever the majority, five or more participants, selected a certain feature for their pantomime production. This was consequently coded as "distinctive" and used for distinguishing distinctive features in the pantomime production of PWA and PWA+SD. However, as this dataset was rather small the established distinctive features cannot be generalized onto a bigger population. Therefore, development of a database with regard to distinctive features in pantomime production holds great benefits for future research as it could provide the possibility for more exact measurement.

Finally, the findings of this study offer clinical implications which may contribute to the field of language therapy. It is promising to see that all groups were able to produce comprehensible pantomimes, derive from different semantic information domains and select distinctive features. This supports the studies of Cicone et al. (1979) and Hogrefe et al. (2012) which argue that other modalities of communication besides spoken language may hold great potential in order to communicate effectively. Moreover, the study of Christopoulou and Bonvillian (1985) showed that therapy which focuses on the non-verbal aspect can be beneficial in terms of a positive attitude towards the used method. The main reason is that the limitations people with aphasia have in their speech production are avoided. Therefore, the level of frustration and disappointment which is often accompanied in speech production is much lower. However, both aphasia and a semantic disorder seem to influence different aspects in the pantomime production process. Language therapist could focus more on the context of the conversation

and pay close attention to the execution of pantomimes. This advice could also be given to people in the direct environment of people with aphasia, such as their partners, colleagues and friends. As the interlocutor pays more attention to the context in which a pantomime is produced, the interpretation of the execution may benefit from this approach. For example, when talking about sports people with aphasia could pantomime *the shape of a tennis racket* instead of *pretending playing tennis*. The first pantomime may be more difficult to interpret, as you have to closely pay attention to see the eventual shape. However, keeping the context of sports in mind it may be easier to assign the intended meaning to the produced pantomime. Eventually, this may lead to improved communication for people with aphasia and their interlocutors.

Conclusion

This study set out to investigate the pantomime production process of PWA, PWA+SD and NBDP. More specific, the use of conceptual knowledge and access to different information domains, the selection of distinctive features and the level comprehensibility were compared between groups. All groups were able to produce comprehensible pantomimes which contained conceptual knowledge and depict distinctive features from different semantic information domains. However, on different aspects both aphasia and a semantic disorder seem to affect the pantomime production process.

The main findings were that a semantic disorder seems of influence on the selection of distinctive features. However, even though NBDP and PWA do not differ in the selection of distinctive features, the level of comprehensibility of the produced pantomimes by PWA is half as low compared to NBDP, which possibly affects the communication process as the interlocutor may not interpret the distinctive feature or pantomime correctly. Aphasia in general (including a semantic disorder) has an influence on the use conceptual knowledge and possibly the accessibility of the functional and associative/encyclopedic semantic information domains during pantomime production. This results in less conceptual knowledge in the pantomime production of PWA and PWA+SD compared to NBDP.

Implications which may be useful for clinical practice relate to speech language therapy and the direct environment of PWA. Therapists could point out the importance to interlocutors of paying more attention to the context and focus less on the execution of pantomimes produced by people with aphasia. Even though the pantomimes may be executed poorly, they may still contain essential information. As the interlocutor pays more attention to the context in which a pantomime is produced, the interpretation of the execution may benefit from this approach. Eventually, this may improve effective communication for people with aphasia and their interlocutors.

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Appendix

Codebook

The data, footage of participants being filmed executing the Boston Naming Test in pantomime form, is coded by following the steps described below using the program ELAN. This codebook is developed by Diela Dautova and reviewed by Karin van Nispen in order for the data to be coded as consistent as possible.

1. **Item number**

   For every pantomime produced, the correct number should be assigned. An overview of the 30 items can be found in Table 2. It is possible that participants produce more than one pantomime per item, it is important to note that every pantomime needs to be coded in ELAN by assigning the correct codes to the specific time lapse in which the pantomime is produced. As can be seen in Figure 7, one item can contain several pantomimes which all should be coded consistently.

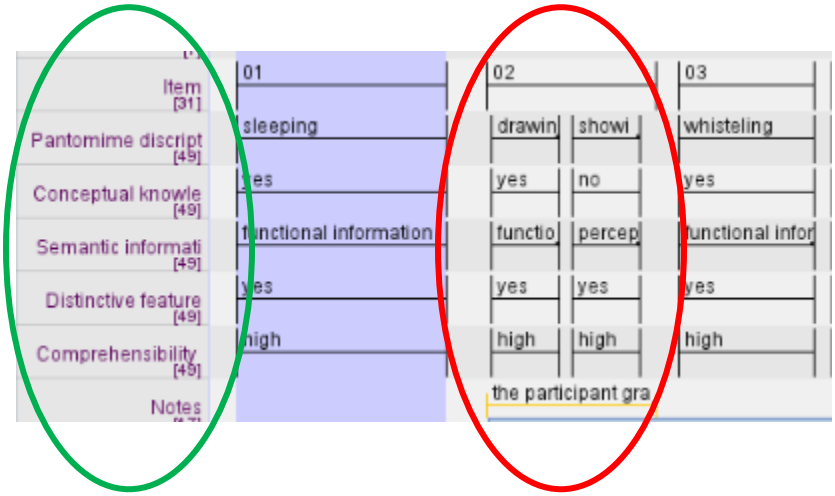

Figure 7. Screenshot of ELAN as an example to illustrate the possibilities of coding. In the green circle the aspects which need to be coded are listed. In the red circle an example of multiple pantomimes per item is shown.

2. **Pantomime description**

   Describe the pantomime being produced by the participant in a way that it is clear what he or she is doing. For example: *sleeping* or *combing hair*. In case a pantomime is produced of which is not clear which concept is being pantomimed, the description of the pantomime will suffice. For

example: *making a big round shape with arms, indicating something large.* When no pantomime is produced or not clearly visible for the coder, this can be coded as *"missing"*..

3. Conceptual knowledge

Establish and code whether conceptual knowledge was present in the produced pantomime. The precept for establishing whether conceptual knowledge was present in the produced pantomime is to judge whether the information which is pantomimed could be derived from the image of the item. During coding the image of the item can be consulted in order to establish which information is present in this image and to which extent it is used in the pantomime production. For example with the item *"domino stones"* the image only illustrates three stones on their sides, with a different number of dots on them. A possible pantomime is that the participants draw small rectangular shapes with their finger and emphasize the dots on them by pointing their finger on the same place as the rectangular shapes. In that case, the registered code in ELAN for "*conceptual knowledge*" would be "*no*". However, it may also be possible that the participants pantomime the act of *knocking down a domino*, by acting like placing domino stones behind each other and knocking down the first stone with their hand or fingers. For this specific pantomime the participants need to possess conceptual knowledge about the item as this action is not illustrated in the image. In the latter case the registered code in ELAN would be "*yes*". In case no pantomime is produced or is not clearly visible this can be coded as "*missing*".

4. Semantic information domain

Establish and code which semantic information domain was present in the produced pantomime. The precept for establishing if a pantomime should be assigned to one of these specific domains is by answering the following questions with a "*yes*".

a. Perceptual information

Does the produced pantomime contain information that is solely provided by the image? For example for the item "*unicorn*" participants can pantomime *the horn*, a pointy object on top of their head using their index finger. In that case the question can be answered with "*yes*", as the horn is clearly illustrated on the image. For this pantomime "*perceptual information*" needs to be selected for coding the semantic information domain.

b. Functional information

Does the produced pantomime represent the act of using a certain object or the object being used for something?

For example for the item "*comb*" the participants can pantomime the act of *combing their hair* by stroking through their hair with their hands or fingers. In this case the question can be answered with "*yes*", as the comb is used for combing hair. For this pantomime "*functional information*" needs to be selected in coding the semantic information domain.

c. Associative/encyclopedic information

Does the produced pantomime contain information that is not represented in the image, is not related to the act of using, yet can be associated with the specific item?

For example the for the item "*igloo*" participants can pantomime the act of *being cold,* bringing both hands flat to the opposite upper arm and rubbing it up and down. In that case the question can be answered with "*yes*". This information is not illustrated on the image, does not relate to the act of using the item, yet it indicates that the participant had to possess specific knowledge about this item, namely: that igloo's are located at places where the temperatures are low. For this pantomime "*associative/encyclopedic information*" needs to be selected when coding the semantic information domain.

ELAN offers the possibility to choose one of the above categories, "*perceptual information*", "*functional information*", "*associative/encyclopedic information*" and an additional category "*missing*" in case there was no (clear) pantomime production.

5. Distinctive feature

Establish and code whether a distinctive feature was present in the produced pantomime. Consult Table 4 to establish whether the pantomime being produced is considered as a distinctive feature. In some cases two distinctive features are assigned for one item. ELAN offers the possibility to choose from three options for establishing the presence of a distinctive feature, namely: "*yes*", "*no*" and "*missing*".

6. Comprehensibility

Establish and code whether the comprehensibility of the produced pantomime is high or low.. ELAN offers the possibility to choose from three options for comprehensibility: "*high*", "*low*" and "*missing* ". Keep in mind that the PWA have their full cognitive abilities, so even though a pantomime may not be executed precisely (which could be influenced by physical limitations of aphasia) this does not mean that the feature that they are trying to pantomime, is not related to the concept. For example for *"helicopter"*, the distinctive feature are the *rotating propellers.* Each participant pantomimes this differently, some very big and noticeable above their head, other very

small in front of them which makes it seem like a rolling item rather than rotating propellers. However, as you know which item is supposed to be pantomimed you can use this in your advantage as you are aware of the context of the item. For example *pointing up in the air* could be related to many items, however as you know that the participant has to pantomime *"helicopter"* you can assign this pantomime to the right category as it is related to the concept. Also keep in mind that some combinations are essential for the level of comprehension. When a participant uses more than one pantomime to communicate an item, the combination of these pantomimes may be an advantage as they complement each other. Also the order may enhance the overall comprehension of the message. So perhaps when the propellers are not pantomimed very clearly, the *pointing up in the air* may indicate the specific item. That is why even though the codebook should be followed precisely, keep in mind that the goal of this study is the depiction of distinctive features in pantomime production. Keep the context of the item in mind and focus less on the possibly poor execution of the pantomime, as this may be influenced by the physical limitations of aphasia. You can use Table 4 to compare the pantomime that is being produced with the description in the table. If the description shows similarity to the observed pantomime, you can code this as *"high",* if the produced pantomime strongly differs from the description you can code this as *"low".*

Table 4

Overview of the 30 items used in the study, accompanied with the distinctive features and their pantomime description per item.

	Item	**Distinctive feature**	**Pantomime description**
1	Bed	Sleeping	Pretending to sleep. Bringing one or two hands (palms against each other) to one ear and tilting the head to that particular side. Possibly closing eyes
2	Pencil	Writing or drawing	Pretending to write or draw. Acting holding a small object (pen or pencil) between forefinger and thumb and moving it around on the table, like writing or drawing something
3	Whistle	Whistling	Pretending to whistle. Acting holding a small object with your fingers and bringing it close to your mouth and blowing air through it
4	Comb	Combing hair	Pretending to comb hair. Stroking through hair with hand or imaginary object which is held in the hand

5	Saw	Sawing	Pretending to saw. Acting holding something in your hand with a firm grip and moving your hand forward and backward
6	Helicopter	Rotating propellers	Making a swirling movement with your hand, mostly circling with your forefinger and repeating it, possibly pointing up or making this movement above the head
7	Octopus	Swimming or floating	Pretending to swim or float. Arms to the side in the air, acting out as if swimming or floating in the water by paddling with arms
8	Clothes hanger	Triangle and a hook	Making a triangular shape with arms or outlining the shape with finger in the air and making a hook shape with hand or finger
		Hanging clothes	Pretending to hang clothes, acting taking of a piece of clothing and hanging it in the closet or on a rack
9	Camel	Two bumps	Outlining the shaping of two bumps or hills in the air close to one another
10	Pretzel	Knot shape	Making a knot shape with your hands by drawing it in the air or using your arms, folding them across each other, making a knot shape
		Edible	Pretending to eat something. Acting holding something in your hands, bringing it to your mouth and taking a bite of it
11	(Tennis)Racket	Playing tennis	Pretending to play tennis. Acting holding something in your hand like a racket bringing it upwards and hitting an imaginary ball
12	Snail	Moving slowly	Acting out moving very slowly with your hand of finger, moving in a straight line forward but very slowly
		Snail shape	Outlining the cochlea shape of the snail in the air or on the table, possibly adding the shape of the feelers
13	Volcano	Eruption	Acting out as if the volcano erupts, by rumbling hands close together followed by bringing them up in the air like something explodes
		Mountain or volcano shape	Outlining a triangular shape with fingers or hands, indicating the shape of a mountain or volcano

14	Arrow	Throwing a dart arrow	Pretending to throw a dart. Acting holding a small object between your fingers, bringing it upwards close to your face, pointing and throwing it
15	Beaver	Gnawing	Pretending to gnaw on something. Acting holding something in your hand and gnawing on it, or tilting head an acting gnawing an vertical object like a tree
		Falling tree	Bringing lower arm up in the air from the elbow and letting it down fast to one side, like a vertical object is falling quickly
16	Rhino	Horn	Outlining the shape of a pointy object pointing up in the air close to own nose
17	Igloo	Half-round shape	Outlining a half round shape in the air with hands
		Cold	Pretending to be cold, by rubbing your hands on the opposite upper arms by crossing them
18	Dominoes	Domino shape	Drawing a small rectangular shape in the air or on the table, possibly accompanied with drawing dots on the imaginary stones
19	Escalator	Walking up stairs	Pretending that the fore- and middle finger are legs and pretending to walk up a stairway
		Moving up or down	Movement with the hand that indicates moving up or down, usually in a straight line
20	Hammock	Hammock shape	Outlining the shape of a hammock in the air (banana shape)
		Resting	Pretending to rest or sleep. Arms folded behind the head, hands underneath head, possibly closing eyes and tilting head back
21	Pelican	Flying	Pretending to fly by holding arms besides the body in the air and moving them up and down
		Beak	Outlining the shape of the beak close to own face, enacting as if having a beak
22	Pyramid	Pyramid shape	Outlining a pyramid, triangular, shape
23	Unicorn	Horn on the head	Outlining a pointy object op top of the head or face
24	Funnel	Funnel shape	Outlining the triangular, funnel, shape with a

			narrow ending
		Pouring into the funnel	Pretending to pour something liquid in to the funnel by holding an imaginary jug or bottle and tilting it downwards
25	Noose	Hanging yourself	Pretending wrapping rope around the neck and hanging yourself, sometimes closing the eyes
26	Drop shutter	Opening and closing the drop shutter	Pretending closing or opening the drop shutter by moving the imaginary handle up and down
		Opening and closing the door	Pretending closing or opening the door by grabbing an imaginary doorknob and moving it forward and backward
27	Scroll	Opening and holding the scroll	Pretending opening, rolling out the scroll with both hands and holding it in front of you
		Reading or writing	Pretending reading from the scroll you hold in front of you or writing on it
28	Sphinx	Enacting the position of the sphinx	Enacting the position of the sphinx that is illustrated on the picture, arms in front of the body like a dog or cat would place them when lying down, palms flat facing down
29	Palette	Holding the palette	Pretending to hold the palette with one hand, arm stretched out from the elbow to the side of the body
		Drawing or painting	Pretending to draw or paint something, possibly acting like dipping the brush into the palette for paint
30	Abacus	Shifting the beads	Pretending to use the abacus by enacting shifting the beads with your hand up and down, possibly counting with fingers

7. Notes

Everything that is outstanding can be written down in the notes section in ELAN. For example when a combination of several pantomimes is used for a certain item which is striking for that particular participant, this can be noted. The notes can serve as clues for certain patterns in the different groups of participants or items.