AN INHERENT BOND: EXTERNAL VISUAL AID HAS A MINOR EFFECT ON THE RATE OF CO-SPEECH GESTURES

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Abstract. Traditionally, the purpose of representational co-speech gestures is to repeat or represent the semantic content of accompanying speech and so to facilitate speech comprehension. To test this belief, each of 22 participants was asked to deliver an informative speech once with the support of visual aid in the form of data-show (DS) projector slides and then to deliver the same speech without using any visual aid (NDS) in a different session; the purpose was to see if using visual aid had any significant effect on gesture rate during speech production. The theoretical framework of the study is based on findings in the Information Packaging Hypothesis, the Gesture as Simulated Action framework and relevant findings in cognitive psychology and neuroscience. The results showed that all participants used gestures during both sessions; the average number of co-speech gestures was 7.2 during the NDS and 6 during the DS sessions. This shows that using visual aid that supports the semantic content of speech did not lead to a significant reduction in the number of co-speech gestures in the DS sessions; it also indicates that the role of co-speech gestures is not merely to repeat the semantic content of accompanying speech. These results confirm previous findings in cognitive psychology that speech and accompanying gesture are cognitively and instinctively connected as one unit and that co-speech gestures possibly have an essential role in facilitating speech conceptualization and production. Speech and co-speech gestures are neurologically interconnected and they are impulsively produced whenever a speaker intends to communicate a message. These findings also add further evidence to relevant research which emphasizes that co-speech gestures are not produced merely as visual aid that aims to supplement speech.

Keywords: *co-speech gestures, speech conceptualization, visual aid, Information Packaging Hypothesis.*

Джарбоу Самер Омар. Інгерентний зв’язок: зовнішній візуальний засіб має незначний уплив на кількість жестів, що супроводжують мовлення.

Анотація. Традиційно метою репрезентативних жестів, що супроводжують мовлення, є повторення або репрезентація його семантичного змісту для полегшення розуміння. Щоб перевірити цю ідею, кожного з 22 учасників попросили генерувати змістовне повідомлення спершу зі візуальним супроводом у вигляді слайдів проєктора для демонстрації даних (ДД), а потім генерувати те саме повідомлення, але вже без використання будь-яких візуальних засобів (НДД) під час іншої сесії. Мета полягала в

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тому, щоб побачити, чи користування візуальними засобами має якийсь значний вплив на швидкість жестів під час породження мовлення. Теоретичні основи дослідження базуються на висновках гіпотези способів подання інформації, теорії жесту як модельованої дії та відповідних висновків у царині когнітивній психології та нейронауки. Результати засвідчили, що всі учасники використовували жести під час обох сеансів; середня кількість жестів, що супроводжувала їхнє мовлення, становила 7,2 під час сеансу НДД та 6 під час сесій ДД. Це показує, що використання наочних засобів, що підтримують семантичний зміст мовлення, не призвело до значного зменшення кількості жестів, що супроводжують мовлення на сесіях ДД. Крім того, це також вказує на те, що роль жестів під час породження мовлення полягає не лише у повторенні його семантичного змісту. Одержані дані підтверджують попередні висновки представників когнітивної психології про те, що мовлення та жести, що його супроводжують, когнітивно та інстинктивно пов’язані як одне ціле, і що жести при цьому відіграють важливу роль у концептуалізації та продукуванні мовлення. Мовлення та жести нейрологічно взаємопов’язані, і вони виникають у мовців спонтанно щоразу вони мають намір передати повідомлення. Ці висновки також слугують додатковим свідчення тих досліджень, які підкреслюють, що супровідні жести виробляються не лише як візуальний засіб доповнення мовлення.

Ключові слова: *жести, що супроводжують мовлення, концептуалізація мовлення, візуальний засіб, гіпотеза способів подання інформації.*

1. Introduction and Background

Empirical evidence shows that humans produce gestures intuitively and spontaneously during speech even when the addressee cannot see them. Iverson and Goldin-Meadow (1998) found that blind participants gesture while talking to other blind participants even though they have never seen such gestures; people produce gestures (co-thought gestures) when they solve problems silently (Chu & Kita, 2011), and even babies would use gestures (Kelly, McDevitt, & Esch, 2009; Bates & Dick, 2002).

Research that investigates the interaction between gesture and speech has been dominated by the following two aspects: ‘timing’ (integration) and ‘meaning’ (function) (Abner et al., 2015). ‘Timing’ basically relates to the observation that gestures are synchronized and integrated with their respective utterances. ‘Meaning’ focuses on the issue that gestures have a role in facilitating the listener’s comprehension of the intended meaning. Within this latter area of research, another area that has gained recent consideration is that co-speech gestures are cognitively helpful to the speaker as well since they facilitate conceptualization of a message (Chu & Kita, 2011; Kelly et al., 2009; Bates & Dick, 2002)

Most research on co-speech gestures typically focuses on the effect of gestures on the addressee’s perception of a message (e.g. Kang & Tversky, 2016; Ping & Goldin-Meadow, 2008). However, since communicative events also involve the producer of a message, it is necessary to investigate why speakers produce gestures. According to the Information Packaging Hypothesis (henceforth IPH) (Kita, 2000; Alibali, Kita, & Young, 2000; Hostetter et al. 2007), “speech and gesture interact at an earlier stage when information is packaged, organized and distributed across the modalities” and so this suggests that gestures are interconnected with conceptualization and production of speech (Wagner, 2014, p. 216). Research in cognitive psychology that focused on this innate synchrony (McNeill, 2014) of speech and co-speech gestures has shown that gesturing reduces cognitive load and so facilitates thinking and memory retrieval during speech production (Goldin-Meadow & Wagner, 2005). The IPH suggests that gesture is associated with preverbal processes related to speech conceptualization as a link has been assumed to exist between increase in cognitive load during speaking and increase in gesture rate.

1.1. Gestures are an innate component of speech production

Neuroscience research suggests that language is processed by a general system of communication with, in Broca's words, "the ability to make a firm connection between an idea and a symbol, whether this symbol was a sound, a gesture, an illustration, or any other expression" (cited in Xu et al. 2009, p. 20668). Research in neuro-psychology, especially that using fMRI (functional Magnetic Resonance Imaging), has experimentally shown that brain regions and systems that are responsible for speech production and comprehension are the same as/intersect with those regions that are responsible for the initiation or comprehension of spatio-motor stimulus (i.e. gestures) (Rizzolatti & Craighero, 2004; see also Schippers et al., 2010; Dick et al., 2009).

Since gestures as action are stimulated by the same brain regions responsible for language conceptualization and perception, this suggests a link between conceptualization of speech and gesture production. Xu et al, (2009) have found that gesture (as behaviour) processing takes place in Broca's and Wernicke's areas in the brain (brain areas associated with language processing), which are the same areas humans use for language comprehension and production. To emphasize the neurological connection between gesture and speech more, research in fMRI has shown that Broca's and Wernicke's areas are connected by a bundle of nerve fibers referred to as the 'arcuate fasciculus' (Bernal & Nolan, 2010); and an overlapping neural network involving Broca's area, Wernicke's area, and the premotor cortex shows more neurological activity when speech is accompanied with gestures than when only either of them occurs (Schippers et al, 2010; Dick et al., 2009). All of these findings are "evidence that action and language processing share a high-level neural integration system" (Willems et al. 2007, p. 2322). This intersecting, interactive networking in the brain enhances language production and comprehension (Vainger et al., 2014; Dick et al., 2009).

According to McNeill (2014), gesture and speech form a 'gesture-speech' unit even before they are expressed externally. McNeill (1992) maintains that speech and accompanying gestures are phonologically synchronous where the gesture 'stroke' is synchronized with the most accentuated syllable, they are semantically synchronous as they are related to the same idea, and are also pragmatically synchronous as they share the same pragmatic function in context. For instance, it has been found that the stroke phase of a gesture "is the most effortful and most meaningful phase of the gesture" and is paralleled to the nucleus of a syllable (Abner et al., 2015, p. 438).

Speech and gesture share a neural system that integrates information from both modalities (Willems et al., 2007) and so gesture and speech can be thought of as forming “a single integrated system” in which they collaborate to express meaning (Goldin-Meadow & Wagner, 2005, p. 238). In addition, the semantic interpretations of speech and accompanying representational (i.e. that embody the meaning of accompanying words) gestures are strongly interconnected in the neural processing of both modalities in the human brain (Kelly et al. 2004). Speech and co-speech gestures can be looked at as what Clark (1996) describes as ‘composite signals’ (p. 161); this interconnectedness has its “origins in early hand-mouth linkages,” and “it is the initial sensorimotor linkages of these systems that form the bases for their later cognitive interdependence” (Iverson & Thelen, 1999, p. 19). Besides, Bates and Dick (2002) found that gestures and language are so closely connected during early developmental stages for both deaf and hearing children.

Gestures also aid the speaker’s thinking and memory retrieval during speech production. Goldin-Meadow and Wagner (2005) found that their participants remember letters and words better when they gesture than when they do not. Goldin-Meadow et al. (2001) describe how participants remembered more words when they gestured during their math explanations than when they did not. According to Kelly et al. (2009, p.330), the reason their participants remember foreign words better when accompanied with gestures is because representational gestures make a deeper ‘imagistic trace’ in the brain for a new word as these gestures embody meaning non-arbitrarily. This result generally applies not only to new words of a foreign language but also to words in the speaker-addressee shared native language (Kelly et al. 2009, p.330). It seems that co-speech gestures help speakers remember the points they want to discuss and also help them remember how to do that in an effective manner as it has been found that “gesturing while speaking frees up working memory resources” which can “then be used for other tasks, such as learning how to solve a new problem” (Ping & Goldin-Meadow, 2010, p. 603).

The spontaneous unintentional production of gestures facilitates speech conceptualization (Chu and Kita, 2011; Goldin-Meadow & Wagner, 2005). The cognitive interconnection between gesture and speech has been mainly focused on by two modes of research in cognitive psycholinguistics; these are the Information Packaging Hypothesis (IPH) and the Gesture as Simulated Action framework (GSA). The IPH holds that “producing gestures helps speakers organize and package visuospatial information into units that are compatible with the linear, sequential format of speech” (Goldin-Meadow & Alibali, 2013, p. 258); findings in the IPH suggest that gesture rate increases according to increase in cognitive demands (see 1.3 below). According to the Kita (2000), during speech conceptualization, gestures help speakers parse spatio-motoric images into smaller chunks to lighten cognitive load on them. These smaller chunks are easier to linearize in articulated speech than a whole multidimensional mental image. Similarly emphasizing the cognitive connection between gesture and speech, the GSA framework (Hostetter and Alibali, 2010) postulates that speaking conceptualizations motivate simulations of action and perception and then these simulations activate corresponding motor and premotor brain areas responsible for providing gestures according to individual and contextual factors. Reflecting on this interconnectedness between the two modalities, Iverson and Thelen (1999) believe that this linkage of speech and gesture is a “manifestation of the embodiment of thought” as both “hand and mouth are tightly coupled in the mutual cognitive activity of language.”

These findings suggest that co-speech gestures would be initiated in any context where a person is involved in speech production; this connection is formed mostly regardless of environmental stimulants since these two modalities are mutually and intuitively stimulating as one cognitive and neurological unit.

1.2. Gestures are Recipient-Designed

The findings that gesture and speech are naturally interconnected suggest benefits for both the speaker (see 1.3 below) and the addressees. But as has been discussed above, in most situations of their occurrence, co-speech gestures are spontaneously, rather than intentionally, produced and so any benefits gained will be the result of this spontaneity of their production.

Thus, recent research in neuroscience has shown that the perception of gestures accompanying speech by an addressee activates specific regions in their brains that are activated when a speaker performs these gestures. Findings in cognitive psychology have shown better learning outcomes, better memory retrievals, and increased brain activity for both speaker and receiver when the two modalities co-occurred (Melinger et al., 2007; Hostetter et al., 2007). According to Kang and Tversky (2016, p.3), gestures “can map meanings more directly than language” (p.3). They add that gestures are more effective than a flat diagram, for instance, in representing actions more directly as gestures “are themselves actions and can be three-dimensional” and so gestures are more capable of expressing visuo-spatial information than speech (Kang & Tversky, 2016, p.12).

We can conclude that in virtue of their natural and impulsive co-occurrence with speech, gestures participate in, and so facilitate, the comprehension of a message and so improve the audience’s attention and conceptualization with regard to speech content.

1.3. Gestures Decrease the Speaker’s Cognitive Load during Speech Production

Some mental tasks are more cognitively demanding than others. Research in this area also emphasizes the link between gesture production and both of thinking and speech production. The results of Alibali et al. (2000), for instance, show that explanation tasks involved high demands on conceptualization processes of what should be said. The task of providing information to others is cognitively and psychologically demanding especially with regard to the processes of ‘linearization’ (i.e. order of ideas), ‘focus’ (i.e. what to mention and what to ignore), and memory retrieval (Hostetter et al., 2007).

Research found an increased rate of gestures during tasks that involved more speech conceptualizations than other ones; and the results link the increased production of gestures to spontaneous effort to lighten cognitive load (Melinger & Kita, 2007; Goldin-Meadow & Wagner, 2005). Cognitive processing of data is expectedly laborious as the speaker is mostly explaining, ordering, and connecting a multitude of ideas, relevant logical arguments, and their supporting major and minor details into a general comprehensible whole that aims to communicate a message.

Goldin-Meadow and Wagner (2005, p.237) suggest that gesturing lightens cognitive load by shifting the load "away from a verbal store into a visuospatial store" and this would make "it easier to perform a verbal task simultaneously"; they add that the cognitive effects of gestures are direct and relate to the point that they reduce cognitive effort since they help externalize ideas (p. 234). Iverson and Goldin-Meadow (1998, p. 228) conclude that co-speech gestures facilitate "the thinking that underlies speaking." This suggests that since speaking is accompanied by (subconscious) thinking, so speech will be always interconnected with gesture conceptualization and production since the link between the two is inevitable (Iverson & Thelen, 1999; Willems et al., 2007; see 1.1 above).

1.4. The Present Study

The findings of many studies in cognitive psychology and neuroscience establish that speech and gesture are intuitively and innately interconnected. The present study compares gesture production during two speech tasks where visual aid as data-show slides is used in one session (hereafter 'DS') and not used at all in the other session (hereafter 'NDS') though each presenters delivered the same informative speech in each session.

We can expect that the DS slides can easily and more vividly represent the images, shapes, sizes, and movements that are related to descriptions mentioned during informative speech. But if speakers are able to enrich their informative speech by depicting visual aid such as showing pictures, drawings, and motion diagrams representing their speech content, would this mean that co-speech gestures would become redundant and so drastically reduce in number during speech production? The Hypothesis in this research is that the participants would still produce a substantial number of representational gestures during the DS session as gestures are instinctively and impulsively interconnected with speech conceptualization regardless of the existence or absence of visual aid in the speech environment. I also hypothesize that gesture rate would be slightly higher in the NDS sessions than in the DS sessions. It is hoped that the results and analysis in this study will contribute to a better understanding of gestural behavior in human communication.

2. Method

Data collection for purposes of this research depended on observation of gestural behaviour during the actual tasks of presenting informative speech.

Observation was performed by three female coders who counted and wrote down the number of observed representational gestures made by each participant. The coders had not been informed about the purpose of data collection.

The data regarding each speech was written down in tabulated format showing only the number of each speaker (to maintain anonymity of the participants), as it appeared in the attendance sheet, in addition to the number of gestures observed during each speech. Participants were instructed to deliver the same informative speech during two separate sessions; each one had her own topic. They were asked to use visual aid to support explanation of their ideas in the DS session while in the NDS session they were not allowed to use any visual aid. Visual aid consisted of data-show slides (the device is controlled by a computer) showing pictures, diagrams, drawings, or motion pictures. In the NDS session, participants could only use an outline printed on a sheet of paper and which participants were asked to place on the table in front of them; this was intended to make sure that their hands were free to express gestural behavior without being hindered. Participants received course credit for the speech presentations. No training, recommendations, or mentioning with regard to gestures were given before the speech sessions. After data collection, participants were informed about the data collection performed by the coders and gave their informed consent that collected data be used on condition of anonymity.

Participants have been divided into groups A and B. Group A (numbers 1–11 in Table 1 below) had to give their DS speech in the first session and the NDS speech in the second session. Group B (numbers 12–22 in Table 2 below) did the opposite and so had to give their NDS speech in the first session and the DS speech in the second session. This was designed to make sure that increase or decrease in gesture rate did not happen because participants got used to one mode of presenting information than the other. For each participant, observation of representational gestures took place only during the first three minutes of her informative speech in each session. The number of participants was 29; they were all females, and their ages ranged from 18 to 21 years. However, the data analysis focused only on data collected with regard to 22 participants. Data collection for the remaining 7 participants was disregarded for several reasons: coder discrepancy with regard to number of observed gestures or due to technical issues. The gesture rate numbers in Tables 1and 2 represent the average of the numbers of gestures as observed by each coder; whenever there was an apparent discrepancy with regard to the number recorded by one of the coders, it was disregarded and an average was taken with regard to the other two coders' numbers.

McNeill (1992) classifies gestures into representational' (also called 'iconic') gestures, deictic gestures, emblems, and beats. Representational gestures resemble the meaning of co-occurring expressions. Deictic gestures, on the other hand, accompany expressions (e.g. 'this' and 'that') that point to referents. Emblems, such as the 'OK' gesture, are conventionalized or 'standardized' (unlike representational gestures) and have a common meaning across the same culture. Beats are hand gestures that are "tightly synchronized with the prosodic contour of the discourse" (Biau et al., 2016, p. 129). Focus in this research was only on representational gestures; an example on representational gestures is when one of the participants moved her forefinger as if repeating the shape of two circles in the air while uttering the word 'repetition'. Another participant used the same gesture while uttering the word 'turn' in 'the turbines would start to turn'.

Video recording had not been used for data collection because we believe that using video-recording or similar instruments would have led to varying degrees of inhibition with regard to verbal and non-verbal behaviors. Each method of data collection seems to have its own advantages and disadvantages. Video-recording for instance can capture full details of the observed audio-visual behaviour; it can be played at slow motion, replayed, paused, clipped, etc. These features are clearly lacking in human observation, but the spontaneity of speech and gesture behaviour can be impaired when the speaker is aware that he/she is being recorded.

3. Results and Discussion

As can be seen in Tables 1 (group A) and 2 (group B) below, the number of representational gestures occurring during the NDS speeches is slightly higher than that occurring during the DS speeches for most participants in both groups; the mean average of the representational gestures produced by participants in both groups was 7.2 in the NDS speech sessions in comparison to 6 in the DS speech sessions.

Table 1.

The number and average of co-speech gestures produced by participants in group A during the DS session (delivered first) and the NDS session (delivered second)

No. of Participant	No. of Gestures in the DS session (delivered first)	No. of Gestures in the NDS session (delivered second)
1.	7	8.6
2.	3.6	5.3
3.	7.3	7.6
4.	5.6	7.3
5.	8.3	10.3
6.	4	5.6
7.	3.6	5.3
8.	5.6	5.3
9.	8.6	9.6
10.	6.3	4.3
11.	8.3	9
Total	68.2	78.2
Average	**6.2**	**7.1**

Table 2.
The number and average of co-speech gestures produced by participants in group B during the NDS session (delivered first) and the DS session (delivered second).

No. of Participant	No. of Gestures in the DS session (delivered second)	No. of Gestures in the NDS session (delivered first)
1.	5.6	7.6
2.	4.3	6
3.	5.6	8.3
4.	4.3	3.6
5.	7.3	9.3
6.	4.3	7
7.	7	8.3
8.	8.3	6.6
9.	5.3	7.3
10.	7.3	10.3
11.	5.6	7.3
Total	64.9	81.6
Average	**5.9**	**7.4**

Participants in group A produced an average of 6.2 representational gestures in the DS session and an average of 7.1 gestures during their NDS session. Participants in group B produced an average of 5.9 gestures during their DS session and 7.4 gestures during their NDS session. As a total view point, therefore, the existence of visual aid content supporting the semantic content during the DS sessions did not lead to the disappearance, or a drastic reduction in the number, of representational co-speech gestures during speech production. This confirms the first part of the hypothesis in this research (see 3.1 below). On the other hand, confirming the second part of the hypothesis, the participants produced a slightly higher number of gestures in the NDS sessions than in the DS sessions (see 3.2 below).

3.1. Gestures are instinctively associated with speech conceptualization

The finding that the participants' gesture rate in the DS sessions was not drastically reduced in comparison to that in the NDS confirms the first part of the hypothesis that participants would still produce a significant amount of gestures during the DS speech despite the existence of visual aid (i.e. pictures, drawings, motion diagrams). Based on the findings in the literature that speech and gesture are functionally, physiologically, and cognitively interdependent (see 1.1 above), we can understand why co-speech gestures did not disappear in the DS sessions despite the use of external supportive visual aid. The finding in this research that all participants still produced a significant number of gestures during the DS sessions is evidence that gestures are instinctively produced during speech conceptualization and production.

Since findings in the literature suggest that speech and accompanying gestures form bonded cognitive units, we can assume that regardless of whether the speaker uses external visual aid during speech, gestures ‘will still leak onto a speaker’s hands’ (McNeill, 2014). Since the findings in IPH (Kita, 2000; Alibali et al., 2000), cognitive psychology (Wagner, 2014; Goldin-Meadow ,1998; Chu & Kita, 2011; Kelly et al. 2009) and neuroscience (Xu et al. 2009; Dick et al. 2009) suggest that gestures are cognitively and neurologically interrelated with conceptualization and production of speech, we can assume that gesture production as in the DS sessions cannot be replaced by external visual aid. The speakers were aware that the visual aid tools that they used represent their speech content; however, they did not stop producing gestures simply because producing or not producing co-speech gestures is not an intentional behaviour that is performed willingly. Since “gestures exist internally and form gesture-speech units” (McNeill, 2014, p.139), they were intuitively associated with speech conceptualization in both the DS and NDS speech sessions. The motor coordination and mutual co-occurrence of hand and mouth (Iverson & Thelen, 1999), their cognitive interdependence that “stays throughout a person’s lifespan” (Wagner, 2014, p. 216), and the structural and functional synchrony of gesture and speech (McNeill, 1989, 1992) all support the findings in this study that gestures would still be produced regardless of the presence of visual aid since the role of gestures is not merely to represent semantic content to the addressee.

Speech and gesture are physiologically bonded to the extent that their shared co-existence “transcends the intentions of the speaker to communicate” (Iverson & Thelen, 1999, p.19). Speakers produce co-speech gestures not merely because they intentionally aim to make their speech content more comprehensible. One of the observations during the participants’ speech tasks was that representational gestures have been mostly associated with spatio-motoric content related to descriptions of shapes, sizes, and movements. According to Melinger and Kita (2007, p.25) the linearization and focusing components of speech conceptualization are both susceptible to such a cognitive load “when planning an utterance with spatio-motoric content.” Since gestures have been associated with decreasing cognitive load during speech conceptualization (Kang & Tversky, 2016; Goldin-Meadow et al., 2001; Melinger & Kita, 2007), and because gesture is the natural imagery with language (McNeill, 2014), we can assume that gestures would decrease cognitive load regardless of the presence or absence of external visual aid. The justification for this conclusion is that gestures have been found in situations where the speaker knows that the addressees cannot see him/her such as in the case of blind speakers addressing blind listeners (Iverson and Goldin Meadow, 1998), when thinking silently (Chu & Kita, 2011), while talking on the phone (Bavelas et al., 2008), or nowadays, based on personal experience, when some instructors are teaching live online classes (without using camera). Morrel-Samuels and Krauss (1992) found that the planning of a gesture precedes the planning of the speech it accompanies as the preparatory movement for a gesture typically precedes the onset of the semantic co-expressive word by an average of almost one second. This suggests how the conceptualization of a gesture is interconnected with that of spoken words especially those with spatio-motoric content. The findings in this study, therefore, emphasize those in the IPH (Wagner, 2014; Abner et al., 2015), the GSA framework (Hostetter & Alibali, 2010), and relevant cognitive psychology (McNeille, 2014) and neuroscience research (Dick et al. 2009), that gestures have an intuitive role in preverbal conceptualization during speaking.

Co-speech gestures are produced spontaneously. One of the indications of these findings with regard to the interconnectedness between gesture and speech is that even if a speaker intentionally decides not to produce co-speech gestures, he/she will continue to produce them impulsively as they are cognitively merged with speech conceptualization.

3.2. A Higher Cognitive Load on Conceptualization Increases Gesture Rate

The result that the participants produced a slightly higher gesture rate in the NDS sessions than during the DS ones confirms the second part of the hypothesis and agrees with those from recent research that suggests a link between increase of cognitive demands and increase in gesture rate (see 1.3 above).

As predicted by the IPH (Kita, 2000; Melinger & Kita, 2007), participants produced more gestures during the NDS speech sessions than during the DS sessions since not using data-show slides as visual aid seems to have made speech production more cognitively demanding than during the DS sessions despite the fact that the participants delivered the same speech. It can be assumed here that the absence of visual data in the environment had increased the cognitive load for the participants during their NDS speech.

However, if we consider the findings in the IPH that gestures help a speaker "organize and package visuospatial information into units that are compatible with the linear, sequential format of speech" (Goldin-Meadow & Alibali, 2013, p. 258), we are more inclined to believe that the slight decrease in gestures in the DS sessions takes place because the accompanying visual aid makes it easier for the speaker to conceptualize some of her own preverbal ideas rather than because the speaker is aware that the audience can now comprehend the speech content as shown in the visual aid. That is, the role of gestures that they help the speaker break apart imagined conceptions into smaller chunks (Kita, 2000) was, in a few instances in the NDS speech, taken over by the visual aid images thus easing the process of conceptualization for the speaker herself with regard to some speech content.

It is noticeable here that gestures were still abundantly produced during the DS sessions. We assume that this mostly happens regardless of the intention to present comprehensible information to the audience. Since the decline in gesture rate during the DS sessions is not drastically significant in comparison to the NDS, we are motivated to believe that the bond between gesture and speech conceptualization is much stronger than to be disintegrated by the mere presence of external visual aid. Speech cannot dissever from gesture and freely reconnect with another element in context; it is intrinsically connected with gesture production.

Though cognitive load seems to have eased a little in the DS sessions, we assume that it had remained relatively high simply because speech, with which gesture shares co-existence, was still produced in the DS sessions.

4. Conclusion

The use of visual aid did not lead to an absence of, or a substantial decrease in, the number of representational co-speech gestures during speech in the DS speech sessions. Representational gestures had been substantially produced in the DS speech sessions. This result supports research in cognitive psychology and neuroscience that gestures are an integral, impulsive, and intuitive part of speech and that gestures and speech share a synchronous interdependence. As for further research, this topic can be investigated with regard to the effect of co-speech gestures on audience comprehension during speech presentations similar to these discussed in this study; the aim in such future research can be to study the effect of the combination of visual aid with gestures on audience conceptualization of communicated messages. Another area for further research would be to compare results concerning gesture production between male and female participants speaking to an audience of the same or the opposite gender to know if gender differences have an influence on both language production and comprehension.

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