Abstract

While observing gesture has been shown to benefit narrative recall and learning, research has yet to show whether gestures that provide information that is missing from speech benefit narrative recall. This study explored whether observing gestures that relay the same information as speech and gestures that provide information missing from speech differentially affect narrative recall in university students. Participants were presented with a videotaped narrative told in one of four conditions: with gestures and no missing verbal information, with gestures and missing verbal information, with no gestures and no missing verbal information, or with no gestures and missing verbal information. Results showed that observing gestures that provided additional information to speech (i.e., when the speech was missing vital information) enhanced narrative recall compared to observing no gestures, while observing gestures that did not provide additional information to speech were no more beneficial than observing no gestures at all. Findings from the current study provide valuable insight into the beneficial effect of iconic gesture on narrative recall, with important implications for education and learning.

Keywords: narrative recall, iconic gesture, additional gestures, overlapping gestures, learning
Filling in the gaps: Observing gestures conveying additional information can compensate for missing verbal content

Our interactions with others, and therefore our ability to communicate with one another, accounts for a substantial portion of our day-to-day lives (Littlejohn & Foss, 2010). When we interact with each other, we do more than just exchange verbal messages: we make eye contact and exhibit certain forms of body language. We might point to objects that are the subject of the verbal message, or we might perform an action to accentuate a spoken message (Kelly et al., 1999). These particular nonverbal movements performed by the hands that occur during communication – defined as gestures – function to provide additional support to verbal messages (McNeil et al., 2000). Although the term “gesture” may be used to refer to numerous types of body or facial movements, the current study focuses on the spontaneous movements of the hands that individuals produce when communicating with one another (Cartmill et al., 2012; McNeill, 1992).

Through providing additional support to verbal messages, gestures may be used purposefully to benefit a learner (Kelly et al., 1999). Indeed, educators themselves have been observed to produce a wide array of gestures when teaching students across the lifespan (Flevares & Perry, 2001; Goldin-Meadow et al., 1999; Pozzer-Ardenghi & Roth, 2004; Tian & Bourguet, 2016). Furthermore, the observation of gesture by a learner has been shown to benefit recall of verbal messages in a variety of areas, including recall of route information (Austin & Sweller, 2014, 2017; Austin, Sweller, & Van Bergen, 2018), speech (Driskell & Radtke, 2003; Kelly & Church, 1998; McNeil et al., 2000), and more recently, narrative recall (Dargue & Sweller, 2018a, 2018b, 2019, 2020; Macoun & Sweller, 2016). As individuals are exposed to and learn from narratives at a young age (Lynch et al., 2008), understanding how and which gestures influence narrative recall may have important implications for education and learning.
Gesture classification

Different types of gestures have been shown to have differential effects on narrative recall (Dargue & Sweller, 2018b). Although gestures can be classified into four main types: deictic, metaphoric, beat, and iconic (McNeill, 1992), the current study focuses solely on iconic gestures. Iconic gestures are hand movements that are semantically related to the content of accompanying speech, and represent a concrete action, object, or attribute (McNeill, 1992). For example, an iconic gesture might involve holding one hand high when talking about a tall individual, to emphasise the fact that they are tall. This gesture reinforces the speech content through conveying the same information as speech. In other words, the same information would be portrayed by the speaker even if the speech content itself was not there.

These “overlapping” iconic gestures are those gestures that match the semantic content of the speech. As another example, gesturing raising one arm above head level while saying “the boy got pushed into the sky” presents parallel information to that presented in speech. However, if an individual was to perform the same gesture, but not present the speech content “the boy got pushed into the sky,” and instead presented the speech “the boy got pushed,” then the gesture would be considered additional. This is because the semantic information about where the boy got pushed is only available through gesture. It is poorly understood, however, whether gestures that provide additional information have a differential effect on learning than overlapping gestures.

Mechanisms underlying gesture’s beneficial effects on recall

While substantive research exists showing the beneficial effects of observing iconic gestures on the recall of verbal messages (e.g., Feyereisen, 2006; Hupp & Gingras, 2016; Kelly & Church, 1998), the mechanisms underlying why iconic gestures benefit recall are currently unclear, with several, non-mutually exclusive, theories existing surrounding why
gestures might benefit recall of verbal messages (Cook, 2018). One theory surrounding how
gesture observation enhances recall is that the observation of a gesture itself activates a
mental simulation of the observed gesture within the learner’s motor system, which in some
situations can lead to the learner imitating the gesture themselves (Hostetter & Alibali, 2008,
2010; 2019; Iani & Bucciarelli, 2017; Ping et al., 2014; Quandt et al., 2012).

Consistent with the theory that observing gestures activates mental simulations, past
research has shown that learners often imitate gestures they have previously observed when
recalling a story (Dargue & Sweller, 2020). Furthermore, learners benefit significantly less
from gesture when they move their hands and arms while observing a gesture (preventing a
motor simulation occurring), as compared to when they are not engaged in a secondary motor
task (Iani & Bucciarelli, 2017; Ping et al., 2014). Such findings suggest that when it is
difficult to mentally simulate an observed gesture (due to simultaneous activation of the
motor system), the ability to understand and benefit from an observed gesture may reduce.

While learners benefit from the observation of gestures when recalling verbal phrases, this
beneficial effect of gesture observation disappears when learners engage in a secondary
motor task during recall (Iani & Bucciarelli, 2018). This lack of a beneficial effect of gestures
when learners engage in a secondary motor task of the hands or arms, during both the
encoding and retrieval of learnt information, highlights the crucial role the motor cortex plays
in encoding and retrieving information from memory (Dijkstra & Zwaan, 2014; Iani &
Bucciarelli, 2017, 2018). Such findings also support the notion that the observation of gesture
may lead to motor simulations, which may then lead to that information being encoded into
memory: by preventing motor simulation activation (by performing a secondary motor task
involving the hands or arms), any beneficial effect of gesture observation can be eliminated.
However, for a motor simulation to be activated at all, a learner must first pay attention to a
given gesture.
Another theory surrounding how iconic gestures enhance recall of verbal information relates to attention. That is, gestures may act as a highlighter to help a learner focus their attention to the accompanying spoken message (Biau & Soto-Faraco, 2013; Holle et al., 2012; Krahmer & Swerts, 2007). Studies have shown that learners pay more attention to material that is accompanied by gestures than material that is not accompanied by gestures. For example, Valenzeno et al. (2003) conducted a study with preschool children who were shown a video where information was presented with speech only or a combination of both speech and gesture. While watching the video, the number of times participants turned their head away was recorded. The results showed that children turned their heads away from the video significantly more when they were presented with speech only compared to a combination of speech and gesture. Such findings indicate that the observation of gestures appeared to capture the children’s attention.

Studies conducted within the neuroscience community have also suggested that gesture observation may capture a learner’s attention, thereby enhancing learning. In studies using functional magnetic resonance imaging (fMRI), the observation of iconic gestures alongside speech increased brain activity in areas pertinent to attention, including the superior temporal sulcus (STS), superior temporal gyrus (STG), and the left inferior frontal cortex, relative to when the speech was not accompanied by gestures (Holle et al., 2008; Hubbard et al., 2009; Willems et al., 2007). These findings are highly informative, as the STS, STG and left inferior frontal cortex have all been established as having a significant role in speech processing and comprehension, suggesting that iconic gestures may not only focus attention on the accompanying speech, but also potentially enhance comprehension (Hubbard et al., 2009).

However, recent research has highlighted that gestures do more than just guide visual attention – gestures also help learners to allocate their attention in such a way that assists
them in interpreting ambiguous spoken messages (Wakefield et al., 2018). In their recent study, Wakefield et al. (2018) found that gestures assisted children’s comprehension of ambiguous speech when the gestures observed were iconic in nature and clarified accompanying speech. Therefore, the combination of gesture’s ability to both direct visual attention and simultaneously add information to accompanying speech appears to be important in how gesture enhances learning. Similarly, neuroscience research has shown that different areas of the brain not associated with attention, such as the motor cortex, activate when gestures are observed (e.g., Fronda & Balconi, 2020, Iani et al., 2018), further highlighting that the relationship between gesture and speech could impact learning.

Given their concrete, semantic relationship to speech, there may therefore be further mechanisms through which iconic gestures could enhance learning. Presenting information through gesture as well as speech means information is conveyed in two different modalities; and presenting information in two modalities can have important implications for recall. These two modalities may prompt the development of two mental representations of the content presented through gesture and speech, as suggested by multimodal learning theory and dual coding theory (Mayer, 2002; Paivio, 1990). These two representations, verbal and nonverbal, can trigger each other, potentially enhancing memory if one of the representations is forgotten or degraded (Paivio, 1990). Gestures which present the same information as that conveyed in speech may function to enhance recall in this way, that is, through triggering information in memory if the speech representation has been forgotten.

Forgotten or degraded information, however, may not be the only circumstance in which the concrete nonverbal information presented by iconic gestures may be required: the nonverbal information may be the only form available. Consider, for example, if the verbal component is missing. Missing information is a particularly crucial factor underlying the
potential beneficial effects of gestures that present information that is additional to the speech content.

Additional vs. overlapping gestures

As mentioned above, many iconic gestures are communicative because they may convey information that is not present in the accompanying verbal description (i.e., additional gestures; Dargue et al., 2019; Hostetter, 2011). This is in contrast to overlapping gestures, which as mentioned previously, relay the same information as speech (Dargue et al., 2019; Hostetter, 2011). According to a meta-analysis conducted by Hostetter (2011), studies that examined the communicative effects of additional gestures found effect sizes that were approximately twice as large as the effects found in studies that examined the communicative effects of overlapping gestures. Hostetter’s (2011) finding therefore highlights that additional gestures, when observed by a learner, may be more beneficial than overlapping gestures. However, a more recent meta-analysis by Dargue et al. (2019) found no significant difference between the effect sizes obtained in studies that investigated the beneficial effect of additional gestures compared to studies that investigated overlapping gestures. These differential findings highlight the need for further research to explore whether there are indeed differential effects of additional and overlapping gestures on learning. While overlapping gestures may benefit learning through mechanisms such as attention and dual coding, as noted above, additional gestures have the potential to function in a different way. McNeill’s (1992) seminal theory, which suggests that gesture and speech make up two parts of a single underlying verbal-gestural system, provides one explanation as to why additional gestures may be more beneficial to learning than overlapping gestures. When speech is presented with an iconic gesture that provides additional information, the learner needs to process both the speech content and the gesture to form a unified representation of the content. However, when a gesture is presented that relays the same information as speech,
less processing of the verbal and gestural content is needed as the learner receives the same information from both gesture and speech. Given the additional processing required when additional gestures are observed compared to when overlapping gestures are observed, it is possible that gestures providing additional information to speech benefit recall more than overlapping gestures in certain circumstances.

Given that iconic gestures enhance learning when they match, but not contradict, accompanying speech (Dargue & Sweller, 2018a), this additional processing could potentially be either beneficial or detrimental to recall dependent on whether the additional information provided through the gesture makes sense when combined with the accompanying verbal phrase. For example, the combination of producing a pumping gesture while stating “Donald Duck first got water out using the lever” would combine logically to suggest Donald Duck first got the water out by pumping the lever, potentially enhancing the observer’s understanding of the event. In contrast, the combination of gesturing driving a car (as though one has both hands on the steering wheel) while stating “Donald Duck first got water out using the lever” would not combine in a logical fashion and might make an observer question whether Donald Duck used a lever to get water or drove a car to get water. In this situation, the additional gesture may instead hinder learning. The current study therefore focuses on additional gestures that do combine logically with speech, consistent with prior research that has investigated the beneficial effect of additional gestures on recall.

The theory that information conveyed through speech and additional gestures is combined to form a single meaning and can thereby enhance learning and subsequently recall is supported by Kelly et al. (1999). In their fourth study presented within the paper, participants were exposed to a video stimulus of an actress making 10 isolated statements about everyday situations that were either accompanied by a gesture providing additional information or no gesture. For example, if the target sentence was “My brother went to the
The actress would produce an iconic gesture depicting shooting a basketball. Participants were then asked to recall what the narrator said in the video segments verbatim. Participants who observed additional gestures recalled significantly more additional information traceable to the gestures produced compared to the no gesture condition, suggesting that information conveyed through iconic gestures is incorporated into what participants consider to be the intended meaning of the spoken message. Similar findings have since been reported by Church et al. (2007), who found that their participants were more likely to recall additional information traceable to gesture when they observed gestures that provided additional information in combination with speech (e.g., “It’s bad in that room” + waving hand in front of nose to suggest it smelled bad) as opposed to speech only. In this same study, participants were also more likely to recall the content of speech when the speech itself was accompanied by gestures, as opposed to when presented with speech only.

If participants indeed combine the information presented in speech and gesture to form a unified meaning, then the learner is likely to perceive the gesture and then create a mental representation of the speech that conveys the meaning behind the gesture.

The idea that additional gestures may benefit recall of information to a greater extent than overlapping gestures is also consistent with research within the neuroscience community which has shown language processing without gestures to involve areas of neural activation similar to those involved in gesture observation (Hauk et al., 2004). As the same areas of the brain are activated when individuals process language and observe gestures, it is possible that gestures which overlap with speech might not benefit recall. If the spoken message being processed is missing the information that is presented in gestures, however, then the gestures have the potential to be more beneficial.

that although gesture may supplement speech, speech is the dominant modality on which we make our judgements. If our judgement of the content is solely based on speech, then observing gestures that carry a different meaning to the accompanying speech may be ignored, and consequently may not have an impact on recall. Consistent with Levelt (1998), past research has found that gestures that contradict accompanying speech have no impact on narrative recall in preschool-age children (Dargue & Sweller, 2018a). However, no research to date has examined whether this same pattern is observed in the context of narrative recall when gestures, rather than providing contradictory content, provide additional information. If gestures and speech remain distinct systems (as theorised by Levelt, 1998) with speech being the dominant modality on which we base our judgement of content, then it would be anticipated that gestures providing additional information would not be of benefit to recall.

Research on whether additional gestures facilitate greater recall of information as compared directly with overlapping gestures is sparse. This is such that to the authors’ knowledge, only two meta-analyses and one experimental study have directly compared the effect of additional gestures on recall to the effect of overlapping gestures on recall, with most research to date looking at these gesture types and their effect on recall separately. Of the limited research that has directly compared the effect of additional gestures on recall to the effect of overlapping gestures on recall, there is evidence that additional gestures may be just as communicative as overlapping gestures (consistent with McNeill, 1992). Austin et al. (2018) examined the effect of overlapping and additional gestures on recall of spatial information when given route directions through an unfamiliar building. When the verbal route directions were edited to be incomplete, but the gestures were kept the same (i.e., the gestures provided additional information), recall of route directions in the gesture condition was comparable to when participants were presented with the direction both through speech and gesture. This finding suggests that additional gestures provide the same benefit to
learning as overlapping gestures and aligns with the finding of Dargue et al.’s (2019) meta-
alysis, which found no significant difference between the effect sizes of studies which
looked at the effect of additional and overlapping gestures on recall of spoken messages.
However, more research directly comparing the effects of additional vs. overlapping gestures
is essential not only to identify what kinds of gestures are most beneficial to recall (i.e.,
additional or overlapping), but also to better understand the way that information is processed
and recalled when accompanied by gestures that clarify or simply reinforce the spoken
message.

In sum, all gestures may draw a learner’s attention to the accompanying speech
content. From there, however, there are crucial differences between different gesture types
that may impact how beneficial gestures are for recall. As concrete, meaningful gestures,
iconic gestures can present information relevant to the speech content, beyond simply
drawing attention. Iconic gestures therefore have an added benefit over other types of
gestures by being able to provide semantic, meaningful information through two modalities
(i.e., gesture and speech). This added benefit could function through dual coding of
overlapping information presented through gesture and speech, or through additional
information presented through gesture beyond the speech content, resulting in enhanced
processing and incorporation of the gestural content into the mental representation of the
message. Understanding whether additional gestures are more beneficial to recall than
overlapping gestures will therefore enhance our knowledge of the way we process and recall
spoken information accompanied by gesture.

Present study

Given the abovementioned mixed findings surrounding whether additional gestures
are more beneficial to recall than overlapping gestures, the current study aimed to ascertain
whether gestures provide greater benefit to narrative recall when they compensate for missing
verbal information than when they relay the same information as speech. This aim was examined using a visual narrative told verbally in one of four conditions. The first condition involved a narrative with no missing verbal information with gestures presented (i.e., the ‘gestures, no missing verbal information’ condition; the gestures were overlapping with the speech content). The second condition involved a narrative with missing verbal information with gestures presented (i.e., the ‘gestures, missing verbal information’ condition; the gestures provided additional information beyond the speech content). The third condition involved a narrative with no missing verbal information with no gestures presented (the ‘no gestures, no missing verbal information’ condition). Finally, the fourth condition involved a narrative with missing verbal information with no gestures presented (the ‘no gestures, missing verbal information’ condition). Participants’ narrative recall was measured through both free recall and specific follow up questions, which covered both phrases that had an accompanying gesture and phrases which did not have an accompanying gesture.

It was expected, firstly, that participants who observed gestures would show better recall of the narrative compared to participants who were shown a narrative with no gestures, averaged across missing and no missing verbal information conditions. Secondly, it was expected that participants shown a narrative with gestures that provided additional information to the corresponding speech content (as the speech content was missing verbal information) would show better recall of the narrative compared to participants who were shown gestures that did not provide additional information (i.e., no missing verbal information), averaged across the gesture and no gesture conditions. The primary hypothesis of interest, however, was an interaction between gesture condition and missing verbal information condition, such that the enhanced recall of the narrative when accompanied by gestures, as compared to no gestures, was expected to be greater for participants who were exposed to additional gestures (with missing speech content) than for those exposed to
overlapping gestures (with no missing speech content). Given the contradictory findings between two meta-analyses regarding the differential effects of additional and overlapping gestures however (Dargue et al., 2019; Hostetter, 2011), these latter two hypotheses are put forward tentatively.

**Method**

**Participants and Consent**

Participants included 109 (81 females, 25 males) undergraduate psychology students recruited via advertisement on the Macquarie University Psychology Participant Pool, aged between 18 years 4 months and 50 years 8 months ($M = 21.26$ years, $SD = 4.86$).

In the sample, 11 students were from an introductory psychology course and 95 students were from a cognitive psychology course. The introductory psychology group included 3 (27.3%) males and 8 (72.7%) females, ranging from 18.33 years to 33.17 years ($M = 20.42$, $SD = 4.35$). The cognitive psychology group included 22 (23.2%) males and 73 (76.8%) females ranging from 18.92 years to 50.67 years ($M = 21.35$, $SD = 4.92$). Three participants were omitted from the study: two resulting from experimenter error and one due to technological error. The final sample consisted of 106 participants. Participants signed a participant information and consent form prior to participating in the study.

**Experimental Design and Power Analysis**

The present study was a $2 \times 2$ between-subjects design, with gesture condition (gesture/no gesture) and verbal information condition (missing information/no missing information) as factors. An a priori power analysis in PASS version 11.0.10 (Power and Sample Size, Hintze, 2011) was run for a two-way between-subjects ANOVA including the interaction. Assuming an effect size ($Cohen's f$) of 0.3 for the interaction term, a sample size of 100 (25 per group) achieves 84% power at a 5% significance level, while a sample size of 88 (22 per group) achieves 80% power. Assuming a Cohen’s f of 0.25, a sample size of 100
achieves 70% power, while a total of 128 participants (32 per group) was required for 80% power. Although we aimed to recruit over 100 participants, with the aim of having sufficient power to detect the smaller of these two effect sizes, only a total of 109 participants were able to be recruited (three of whom had to be excluded as noted above). Participants were randomly allocated to one of four conditions, gesture, no missing verbal information (n = 26), gestures, missing verbal information (n = 28), no gestures, no missing verbal information (n = 26) or no gestures, missing verbal information (n = 26). The dependent variable of interest was recall of the narrative, where higher scores indicated greater comprehension of the narrative.

Materials and Procedure

The Peabody Picture Vocabulary Test-4 Form A (PPVT-4; Dunn & Dunn, 2007) was used to measure participants’ receptive vocabulary, as vocabulary is an essential aspect of comprehension (Joshi, 2005). The PPVT-4 was used to ensure any differences between conditions in narrative recall were not solely due to differences in receptive vocabulary level. The primary stimulus was a 2-and-a-half-minute video narrative watched by participants on a laptop computer (video narratives available on request). The narrative was based on an existing video used by Dargue and Sweller (2018b, 2019, 2020) with both preschool-aged children and adults, wherein the character Donald Duck tried to refill a bucket of water to allow him to water his garden. After numerous attempts of filling his bucket with water, the bucket broke, leaving Donald Duck frustrated while watching the remaining water sink into a hole in the ground (see Appendix A for narrative script for the missing verbal information condition and Dargue & Sweller, 2018b for full narrative). Recorded by a video-camera, the narrative was told by an adult female unknown to participants. To reduce variability between conditions and the potential for distraction, there were no props, the narrator sat against a plain white wall, had the same hairstyle, and wore the same clothes for all conditions.
Each of the four conditions required a separate video. In the gestures, no missing verbal information condition, the narrator gestured in a way that matched the content of the narrative (e.g., the narrator held one finger up as she stated that one of Donald Duck’s watermelons had won first prize at a local fair). In the gestures, missing information condition, the narrator produced the same gestures as in the gestures, no missing verbal information condition, however, some words were changed or omitted so that the gesture conveyed additional information to the narrative. For example, the narrator held one finger up as she was speaking of Donald Duck’s watermelons and stated that “one of them had won a prize,” instead of specifically stating it won first prize (see Appendix B for a full list of gestures with their corresponding speech phrases). In the no gestures, no missing verbal information condition, the narrator told the same narrative as in the gestures, no missing verbal information condition but did not produce any gestures to support the narrative. In the no gestures, missing verbal information condition, the narrator told the same narrative as in the gestures, missing verbal information condition but did not produce any gestures in order to provide additional information about the narrative. The narrator presented the verbal component of each video keeping prosody and speech rate constant between narratives and maintained a neutral facial expression.

Recent research has suggested that iconic gestures are not a homogeneous set and can be classified into sub-categories – as typical or atypical (Dargue & Sweller, 2018b). Dargue and Sweller (2018b) defined typical gestures as those gestures frequently used by individuals to depict particular objects or events within a body of speech, and any gestures not commonly used unprompted, but which could still depict phrases in the narrative, as atypical gestures (see Dargue & Sweller, 2019 for a description of typical and atypical gestures). Following their identification, Dargue & Sweller (2018b) compared narrative recall of participants who observed a narrative with typical gestures and participants who observed the narrative with
atypical gestures. Importantly, observing typical gestures significantly enhanced narrative recall relative to no gestures, while no difference in narrative recall was found between observing atypical gestures and no gestures. Given that typical gestures were found to enhance narrative recall, whereas atypical gestures were not, the same iconic gestures that were determined as “typical” by Dargue and Sweller (2018b) were used for the present study.

The narrative contained 10 phrases that were accompanied by gestures (‘gesture phrases’) and six phrases that were not accompanied by gestures (‘non-gesture phrases’). For example, the narrator gestured on the phrase “Donald Duck picked up the bucket and took it back to the water station,” but did not gesture on the phrase “the water kept spurting out of the water station.” The gesture and non-gesture phrases were the same between the two gesture conditions. Furthermore, the narrative contained 47 non-manipulated phrases that were not manipulated for either gesture or missing information and were identical across conditions. These phrases served as a filler to ensure that the narrative flowed. The narrative contained 63 phrases in total. All videos were of approximately equal length, ranging from 2 minutes 22 seconds to 2 minutes 30 seconds.

After viewing the narrative on a MacBook via QuickTime Player, participants were given a join-the-dots filler task, which took approximately 2 minutes to complete. This provided a break between viewing the narrative and subsequent recall in order to prevent a ceiling effect. After completing the join-the-dots task, participants were asked the free recall question. The experimenter stated, “First, tell me everything that you can remember about the story that you saw earlier.”

After the free recall question had been answered, the experimenter stated, “Now I am going to ask you a few more questions about the story that you saw earlier. The questions I am going to ask will not necessarily be in the same order as what you saw in the video.” The free recall question was always asked prior to the specific follow up questions in order to
prevent participants being prompted by the specific follow up questions. The 16 specific questions were asked in a different random order for each participant as specified by a random number generator (http://www.randomizer.org/). The questions consisted of 10 questions that related to gesture phrases (i.e., phrases accompanied by gesture) in the narrative, and 6 questions that related to non-gesture phrases (i.e., phrases not accompanied by gesture). Each specific question was presented initially as an open-ended question (e.g., “What was Donald Duck doing to get the water into the bucket?”). If the participant responded incorrectly or ambiguously to the open-ended question, a follow-up forced-choice question was presented (e.g., “Was Donald Duck pumping or turning on a tap to get the water into the bucket?”). Finally, participants completed the PPVT-4 before being thanked for their time and awarded 30-minutes of course credit for their participation.

Participant responses to all questions were recorded on a video camera to allow for the transcribing and coding of both verbal and gestural information at a later time. Participants were informed that their verbal responses to questions would be recorded prior to obtaining informed consent and the commencement of the study. The experimenter obtained further verbal consent from all participants prior to turning on the camera. All participants agreed to the recording.

Transcribing and Coding

Before coding, the experimenter transcribed the verbal and gestural content of all interviews. Responses that were coded as correct accurately depicted the verbal information presented in the narrative. Non-responses and responses that did not provide an accurate depiction of the verbal content of the narrative were instead coded as incorrect. For free recall, only verbal recall was coded, as on examination of the gestures, their meaning was frequently not reliably clear, nor was which phrase from the narrative the gestures referred to. For specific questions, however, both verbal and gestural recall was coded, as outlined below.
No priority was given to verbal or gestural recall; if either modality expressed correct recall, the score was given.

The free recall question was scored in accordance with the number of items the participants accurately recalled from the narrative, such that each accurate item recalled was given a score of 1. The number of items recalled was then summed to obtain a total score. Based on the 63 events and objects that were presented within the narrative, this total score had a potential ceiling score of 63.

Answers to the specific questions were coded such that a participant received a score of 2 if they answered the open-ended question correctly. When the open-ended question was answered correctly, the follow up forced-choice question was not asked. If a participant answered the open-ended question incorrectly but the follow up question correctly, they received a score of 1. If a participant answered both the open-ended and follow up questions incorrectly, the participant received a score of zero. The score obtained by each participant was summed to yield a total score with a potential ceiling score of 20 for gesture items and 12 for non-gesture items.

Reliability

A total of 20% of the transcripts were independently coded by a second coder to evaluate inter-rater reliability for the dependent variables of interest. Intra-class correlations (ICC) were obtained using an absolute agreement model for free recall, specific questions about gesture items, and specific questions about non-gesture items. For free recall ICC = .76, \( p < .0005 \). For specific questions relating to gesture items, ICC = .94, \( p < .0005 \), and for specific questions relating non-gesture items, ICC = .92, \( p < .0005 \).
Results

Preliminary Analyses

Key dependent variables including free recall (skewness = .752; kurtosis = .376), recall of specific questions related to gesture (skewness = .003; kurtosis = -.480), and recall of specific questions not related to gesture (skewness = -.427; kurtosis = .167) were normally distributed with skewness and kurtosis values between ± 1. Significant, positive correlations were found between participants’ free recall scores and PPVT-4 scores ($r = .409, p < .0005$) and recall of specific non-gesture items and PPVT-4 scores ($r = .289, p = .003$). There was similarly a positive correlation between recall of gesture items and PPVT-4 scores ($r = .171, p = .08$), however, this correlation was non-significant.

Given the significant, positive correlations between language ability and narrative recall noted above, a two-way between-subjects ANOVA with gesture condition and verbal information condition as factors was conducted to ensure there were no significant differences in scores on the PPVT-4 across the four conditions. There were no significant main effects of gesture condition, $F(1, 102) = 1.199, p = .276, \eta_p^2 = .012$, (see Table 1), or verbal information condition, $F(1, 102) = .258, p = .613, \eta_p^2 = .003$. No significant interaction was found between gesture condition and verbal information condition on PPVT-4 scores, $F(1, 102) = .062, p = .802, \eta_p^2 = .001$. As there were no differences between PPVT-4 scores between conditions, PPVT-4 scores were not included in subsequent analyses.

As this decision was based on a null effect, however, a Bayesian two-way ANOVA was conducted to establish whether there was evidence for (or against) including PPVT-4 scores as a covariate. The model was run using JASP’s default priors for ANOVA models, of a uniform prior model probability. That is, all models are equally plausible, including the null model, the gesture condition only model, the verbal information condition only model, the additive model, and the full model with the interaction. The shape parameter of the prior
distribution for the fixed effects was set to the default value of 0.5. The Bayesian two-way ANOVA indicated that the data were 45 times more likely to occur under the null model, compared to the model including the main effect for verbal information, the main effect for gesture, and the interaction between verbal information and gesture (BF\textsubscript{01} = 45.184). In other words, the data were 0.02 times as likely (i.e., far less likely) to occur under the model with the main effect and interaction terms than the null model (BF\textsubscript{10} = 0.022). These Bayes Factors suggests very strong evidence in favour of the null model, suggesting no justification for including PPVT-4 scores in subsequent analyses as a covariate. Furthermore, the BF\textsubscript{M} for the model including the main effects and interaction was 0.053, indicating strong evidence against this model beyond all other models run (including the null model, separate main effects models, and the additive model).

Two chi-square tests of independence were performed to assess the distribution of gender across the gesture and verbal information conditions. There was no significant relation between gender and gesture condition, \( \chi^2 (1, N = 106) = .631, p = .427 \) or gender and verbal information condition, \( \chi^2 (1, N = 106) = .113, p = .736 \), indicating that there was an even distribution of gender across the four conditions (see Table 2).

A two-way between-subjects ANOVA with gesture condition and verbal information condition as factors was conducted to ensure there were no significant differences in age across the four conditions. There were no significant main effects of gesture condition, \( F(1, 102) = .173, p = .678, \eta_p^2 = .002 \), (see Table 1), or verbal information condition, \( F(1, 102) = .121, p = .728, \eta_p^2 = .001 \). No significant interaction was found between gesture condition and verbal information condition on age, \( F(1, 102) = .236, p = .628, \eta_p^2 = .002 \).
The Effect of Gestures on Free Recall

The effect of observing gestures that provided additional information with missing speech or overlapping information with complete speech on free recall was examined using a two-way between-subjects ANOVA with gesture condition and verbal information condition as factors. There was no significant main effect of gesture condition, averaging across the verbal information condition, \( F(1, 102) = .009, p = .924, \eta^2_p = <.0005 \), and no significant main effect of verbal information condition averaging across gesture condition, \( F(1, 102) = .234, p = .630, \eta^2_p = .002 \). No significant interaction was found between gesture and verbal information on free recall scores, \( F(1, 102) = 2.510, p = .116, \eta^2_p = .024 \) (see Table 3).

< Table 3 goes here >

The Effect of Gestures on Specific Questions Relating to Gesture Phrases

The effect of observing gestures that provided additional information with missing speech, or overlapping information with complete speech on specific questions relating to gesture phrases was examined using a 2 (gesture condition) x 2 (verbal information condition) between-subjects ANOVA. Averaged across verbal information condition, there was a main effect of gesture condition, \( F(1, 102) = 14.310, p < .0005, \eta^2_p = .123 \). Averaged across gesture condition, there was a main effect of verbal information, \( F(1, 102) = 30.165, p < .0005, \eta^2_p = .228 \). However, these two main effects will not be interpreted further as a significant interaction was found between gesture condition and verbal information condition, \( F(1, 102) = 8.193, p = .005, \eta^2_p = .074 \) (See Figure 1).

< Figure 1 goes here >

Simple effects analyses were conducted using Bonferroni adjusted alpha levels of .025 to interpret the interaction between gesture condition and verbal information condition. The difference in recall between participants in the gesture condition compared with participants in the no gesture condition was not significant within the no missing verbal
information condition, $F(1, 102) = .416, p = .520, \eta^2_p = .004$. However, there was a significant difference in recall for the gesture condition compared with the no gesture condition in the missing verbal information condition, $F(1,102) = 22.489, p = <.0005, \eta^2_p = .181$, such that participants in the missing verbal information gesture condition performed significantly better on questions relating to gesture phrases compared with participants in the no gesture condition.

**The Effect of Gestures on Specific Questions Relating to Non-Gesture Phrases**

The effect of gestures that provided additional information with missing speech or overlapping information with complete speech on questions relating to non-gesture phrases was examined using a two-way between-subjects ANOVA with gesture and verbal information conditions as factors. There was no significant main effect of gesture, averaging across the verbal information condition, $F(1,102) = .019, p = .890, \eta^2_p = <.0005,$ and no significant main effect of verbal information condition, averaging across gesture conditions, $F(1,102) = 1.874, p = .174, \eta^2_p = .018$ (See Table 3). No significant interaction was found between gesture and verbal information, $F(1, 102) = 3.239, p = .075, \eta^2_p = .031$.

**Discussion**

The current study explored whether observing typical iconic gestures that overlapped with speech and typical iconic gestures that provided additional information to compensate for missing speech content differentially impact recall of a narrative, told through speech only or a combination of gesture and speech, in university students. In other words, this study investigated whether any beneficial effect of observing gesture on narrative recall differed depending on whether the gestures observed provided additional or overlapping information. Overall, the present study found that gestures facilitated narrative recall when they provided additional information yet appeared to provide no benefit to narrative recall when they
No significant differences in free recall were found between the gesture and no gesture conditions, irrespective of whether these gestures provided additional information to missing speech or overlapping information to complete speech. Similar results were found in past research by Dargue and Sweller (2018a, 2019, 2020), such that the observation of iconic gesture provided no benefit to free recall of a narrative compared to observing no gestures at all. The failure to obtain significant results for free recall in these studies has been suggested to be due to participants being able to recall both gesture phrases and non-gesture phrases from the narrative. As a result, the effects of the gesture manipulation may potentially have been diluted for free recall, as the inclusion of non-gesture phrases in free recall may have weakened the observed effect of gesture on narrative recall. Nonetheless, this finding highlights that although the observation of gesture may enhance recall of narrative phrases directly accompanied by gesture, observing gesture does not necessarily enhance recall of a narrative as a whole. This finding therefore has practical implications for the use of gesture in a learning context by suggesting that gesture may be more likely to enhance learning of narratives when gesture accompanies key ideas or steps crucial to understanding the narrative being taught.

Although past research has suggested that gesture can benefit free recall of learnt content (Dargue et al., 2019; Iani & Bucciarelli, 2017; Igualada et al., 2017; Sweller et al., 2020) the heterogeneity within the literature suggests that a generalized effect of observing gesture on learning (such that the gesture enhances learning of content not directly accompanied by gesture) may be circumstantial, and somewhat dependent on the amount of content provided. For example, Sweller et al. (2020) examined gesture’s effect on recall of Japanese verbs, while Iani & Bucciarelli (2017) investigated gesture’s effect on recall of
sentences, rather than narrative recall. Therefore, while gesture has been shown to enhance free recall of learnt content in prior research, such a finding is yet to be found with regards to narrative recall (Dargue & Sweller, 2018a, 2019, 2020), and this discrepancy likely relates to the degree of information presented without accompanying gestures. In verb or sentence learning, relatively little information is provided without gestures. In narrative learning however, the majority of phrases are not accompanied by gesture, as performing iconic gestures continually, for example, would render the narrative highly artificial. The greater degree of information provided without accompanying iconic gestures in narrative learning perhaps reduces gesture’s benefits for free recall.

While it would be possible to split free recall into gesture and non-gesture phrases, comparing the effect of observing gesture on free recall as a whole compared to specific questions allowed investigation into two separate aspects of narrative recall. Free recall, collapsing as we have across the entire narrative, has been used as a measure of gesture’s effect on overall narrative recall. The specific follow-up questions, split between questions targeting gesture phrases and questions targeting non-gesture phrases, have been used to differentiate whether gestures benefit only the phrases that they specifically accompany. Analyzing both gesture and non-gesture phrases separately as well as together for free recall would inflate error rates by repeatedly testing the same data. As a result, for the current study it was opted to test overall recall of the narrative through free recall and recall of gesture vs non-gesture phrases through specific questions. It is also possible that there were differences in the centrality of the information present in free recall and specific questions. For example, the specific questions may not have tapped into aspects of the narrative that participants saw as being most central to the story. As such, future research on this topic should consider controlling for these potential differences through considering the salience of the different points of the narrative and how they map onto the specific questions asked.
As expected, in the missing verbal information condition, participants who observed gestures recalled significantly more gesture phrases from the narrative than participants who observed no gestures. However, in the no missing verbal information condition, no significant difference was found in recall of gesture phrases between participants who were exposed to gestures and participants who were not exposed to gestures. While these results indicate that gestures may benefit narrative recall when they provide additional information beyond speech content, but not if they provide information that overlaps entirely with speech content, such findings are inconsistent with research suggesting that overlapping iconic gestures can indeed enhance recall (Dargue & Sweller, 2018b, 2019, 2020).

Despite these inconsistencies, the findings from the present study are consistent with research suggesting that learners notice information that is conveyed through gestures and are able to use this information to inform their knowledge of the speaker’s meaning (Cassell et al., 1994; Kelly & Church, 1998). While research has found that gestures that provide additional information to speech benefit learning of spatial information (Austin et al., 2018) and comprehension of spoken messages (Kelly, 2001), it was not known until the present study whether additional gestures benefit narrative recall specifically.

Iconic gestures have been suggested to capture a learner’s attention (Valenzeno et al., 2003), and as such it is possible that iconic gestures providing additional information may capture more of the learner’s attention than do overlapping gestures, due to their increased salience. When observing additional gestures, the learner is required to infer meaning from the gesture in order to fully process the information presented. When observing overlapping gestures, however, the information is presented to them by both speech and gesture, leaving less ambiguity regarding the meaning of the information presented. Therefore, it may be that gestures providing additional information to accompanying speech require more processing
from the learner to comprehend the meaning behind the gesture, leading to greater comprehension or recall of the presented information.

However, it is difficult for the present study to conclude that additional gestures were more beneficial for narrative recall because they capture more of the learner’s attention, as the current study did not directly measure participants’ attention. To determine the role of additional gestures in capturing a learner’s attention, future research could utilize eye-tracking technology to determine whether participants fixate on the narrator more when the narrator is producing gestures.

Although inconsistent with Levelt (1998), the findings of the current study are consistent with McNeill’s (1992) seminal theory, which proposed that speech and gesture are processed as an integrated system. According to McNeill (1992), when speech is presented with an iconic gesture that provides additional information, the learner needs to take notice of the surrounding speech content to infer meaning from the gesture in order to process the full cognitive representation of the content. However, when an observed gesture relays the same information as speech (i.e., is overlapping), the information presented in gesture does not need to be processed as deeply as when the gesture provides new information that is not present in speech. As a result, it would be expected that iconic gestures which provide additional information would enhance narrative recall to a greater extent than overlapping gestures, given the additional processing of information required to arrive at a unified meaning. Consistent with this theory, observing additional iconic gestures benefited narrative recall beyond observing no gestures, while observing overlapping iconic gestures did not, suggesting that gesture and speech may be processed as an integrated cognitive system.

Given research that has shown that similar areas of the brain are activated when we process language and observe gestures (Hauk et al., 2004), it is also possible that gestures which overlap with speech do not benefit recall due to the same areas of the brain being
activated. In contrast, it is possible that gestures that provide additional information to speech activate different areas of the brain, which may make them more likely to benefit recall than overlapping gestures. However, further research is necessary to ascertain whether observing gestures that provide additional information to speech indeed leads to different areas of the brain to be activated compared to overlapping gestures.

The construction-integration model of discourse comprehension by Kintsch (1988) provides a further possible reason for the discordant results obtained between additional and overlapping gestures. In addition, the model offers an explanation of what may happen to information provided through speech and gesture after it has been integrated to form a unified representation of the discourse. According to Kintsch (1988), comprehension is comprised of two stages: construction and integration. During the construction stage, a mental representation of the discourse is formed as a network of propositional nodes. In relation to the current study, this stage would represent the integration of information provided through both speech and gesture, as theorised by McNeill (1992). Integration, however, involves the subsequent trimming of the constructed network until any unwanted/incoherent elements of the discourse representation are removed. This is such that any redundant information present within the network at the integration phase will be trimmed from the model. Therefore, consistent with Kintsch (1988) it is possible that there was no benefit of gestures when presented with no missing information due to the overlapping or redundant information being removed at the integration phase. In contrast, when the gestures provided additional information to speech, the information provided by the gestures may have been retained and integrated to allow for coherence of the spoken message leading to better memorisation of the content and subsequently better recall.

Questions about the non-gesture phrases in the narrative were included only to assess participants’ recall of the general information in the narrative. All participants received
enough information to be able to recall the correct answers irrespective of what condition
they were allocated to. Therefore, the present study hypothesised that no significant
differences in correct recall of specific questions relating to non-gesture phrases will be
evident between the four conditions. As predicted, no differences in recall of non-gesture
phrases was found between participants who observed gestures and participants who
observed no gestures, irrespective of whether the gestures were additional or overlapping.
These results are consistent with past research that found no differences in recall of non-
gesture phrases between participants exposed to narratives with gesture compared with no
gesture (e.g., Dargue & Sweller, 2018a, 2018b), and suggest that if gestures are drawing
attention to a narrative, they are not doing so indiscriminately. Rather, they may serve to
highlight the key phrases that they accompany, rather than capturing attention overall.

It is possible that the narrator’s speech itself differed between conditions in the
current study. Effects seen may therefore be due to speech differences between conditions,
rather than direct effects of observing gesture. This is unlikely to be the case, however, as
precautions were taken by the narrator and researchers to ensure the narratives were
presented as similarly as possible. Specifically, the narrator was instructed to use the same
tone, pitch, and frequency in speech in all four narratives in order to reduce variability
between conditions and the potential for distraction. Nonetheless, future research in this area
should include an audio-only control study. This is such that the audio-only components of
each video narrative are presented to participants and their impact on narrative recall
compared to ensure that subtle differences in the narrator’s speech cannot explain any effects
of observing gesture reported.

Despite the abovementioned limitation, the results of the current study have
theoretical implications surrounding under what conditions gestures may benefit learning, as
well as practical implications for educators. While past research has explored the effect of
observing overlapping gestures on narrative recall (i.e., Dargue & Sweller, 2018a, 2018b, 2019, 2020; Macoun & Sweller, 2016), to the authors’ knowledge, this is the first study to show that additional gestures, but not overlapping gestures, enhance narrative recall in university students. This study therefore extends on what was previously known about when gestures enhance narrative recall most, and suggests that certain kinds of iconic gestures (i.e., those providing additional information) could be used by educators to potentially enhance their students’ recall. Providing gestures as an integral part of a verbal message can enhance recall of the content, in particular if these gestures can compensate for missing speech content. In classroom situations, teachers should be encouraged to gesture as they teach; although not all gestures will provide information in addition to that conveyed through speech, the potential for gesture to augment learning should not be understated. Important conceptual content can be conveyed through gesture, and used to students’ benefit in instructional settings. However, further research will be required to ascertain the external reliability of the current findings (e.g., using curriculum or lecture-based materials as opposed to a lab-based narrative).

Future research might also consider a closer examination of participants’ own gestures that they produced during recall. Although participants’ gestures were coded for recall and contributed to scores on specific questions, gestures were frequently ambiguous during free recall, and were not coded. Further analysis of the gestures produced is warranted, such as whether gesture-speech mismatches occurred during speech. It is possible that such mismatches contributed to the ambiguity of meaning noted here for gestures produced during free recall, which prevented these gestures from contributing to recall scores.

Through highlighting the differential effect of additional and overlapping gestures on narrative recall, the current study furthers our understanding of under what conditions gesture benefits narrative recall most. Although the observation of additional gestures benefited
narrative recall to a greater extent than observing no gestures, overlapping gestures were found to be no more beneficial than observing no gestures at all. Such findings extend our understanding of the types of gestures that may enhance learning most and provides educators with guidance on the kinds of gestures that may benefit student learning.
Declarations

Compliance with ethical standards and ethics approval

This study was approved by the appropriate institutional and/or national research ethics committee (Macquarie University Human Research Ethics Committee; Reference Number: 5201800134) and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or a comparable ethical standard.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Conflict of interest

The authors declare that they have no conflict of interest.

Author Contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by Megan Phillips, and all authors contributed to the data analysis process. The first draft of the manuscript was written by Nicole Dargue and Naomi Sweller and all authors commented on subsequent versions of the manuscript. All authors read and approved the final manuscript.

Availability of data and material

Supplied on request by contacting the corresponding author, Nicole Dargue.

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https://doi.org/10.1016/j.jml.2010.04.003


Gesture helps learners learn, but not merely by guiding their visual attention.

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Appendix A: Narrative Gesture and Non-Gesture Phrases (Missing Verbal Information Conditions)

Donald Duck had a garden full of watermelons and one of them had won a prize \[**first prize gesture**\] at a local fair. While watering his garden, Donald Duck noticed that he had run out of water, so he \[**skipped**\] over to a water station to refill his bucket.

When Donald Duck first got \[**pumped gesture**\] water out using the lever, the water did not fill up the bucket because the water only \[**dribbled out**\]. When Donald Duck tried to use the lever again, the water came out too far. This \[**frustrated**\] Donald because he could not seem to fill up his bucket with water.

After using the lever again, the water finally went into the bucket. However, the water kept \[**spurting out of the water station**\] and pushed the bucket over to a ledge, where it began to move \[**tilt back and forth gesture**\]. Donald rushed over to the ledge to try and stop the bucket from falling, but it was too late. The bucket had fallen off the ledge, spilling all of the water onto the ground.

Donald Duck \[**picked up gesture**\] took the bucket back to the water station. This time, Donald Duck moved the lever up and down so fast that the water station began to change shape \[**expand gesture**\], but only a drop of water came out. Donald duck looked into the tap to see why the water was not coming out, and all of a sudden, water began spurting out \[**gesture towards eye**\].

Donald Duck then moved the lever up and down as fast as it could go. A stream of water spurted out, and he chased it with his bucket \[**back and forth gesture**\]. He continued to chase the water all the way back to the water station, but he ran so fast that his beak got stuck in the nozzle and water burst out of him \[**gesture burst out of his nose**\]. Donald Duck slammed the bucket down in front of the water station and moved the lever up and down once more. The pressure in the water station built up so much that water came blasting out which caused Donald Duck to get pushed \[**gesture up in the sky**\].
When Donald Duck landed back on the ground, he noticed that his bucket had been filled up with water. As he went to get it, something happened to the bucket [the bucket broke gesture], leaving the water sitting there in the shape of a bucket. Donald Duck watched as the water burst. He looked down at the puddle quacking angrily and watched as [the water slowly disappeared into a hole in the ground].

**Bold** = Gesture Phrase  
*Italic* = Non-Gesture Phrase
Appendix B: Gestures and Corresponding Speech Phrases for Missing and Non-Missing Verbal Information Conditions

<table>
<thead>
<tr>
<th>Target</th>
<th>Gesture Description</th>
<th>Verbal Phrase – No Missing Verbal Information</th>
<th>Verbal Phrase – Missing Verbal Information</th>
<th>Associated Interview Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>First prize</td>
<td>One hand moved from lap up to chest height and index finger held up to indicate the number one.</td>
<td>“one of them had won first prize at a local fair”</td>
<td>“one of them had won a prize at a local fair”</td>
<td>Donald Duck win at the fair?</td>
</tr>
<tr>
<td>Pumping</td>
<td>Two fists formed with hands; fists then moved up and down together twice.</td>
<td>“When Donald Duck first pumped water out using the lever”</td>
<td>“When Donald Duck first got water out using the lever”</td>
<td>Donald Duck doing to get the water into the bucket?</td>
</tr>
<tr>
<td>Wobbling</td>
<td>Palms facing together shoulder width apart, fingers pointing upwards. Hands tilt to the right then left twice.</td>
<td>“where it began to tilt back and forth”</td>
<td>“where it began to move”</td>
<td>What happened to the bucket when it was on the ledge?</td>
</tr>
<tr>
<td>Picked up</td>
<td>One hand in a fist, raised upwards from hip to shoulder height.</td>
<td>“Donald Duck picked up the bucket”</td>
<td>“Donald Duck took the bucket”</td>
<td>Donald duck do after the bucket</td>
</tr>
<tr>
<td>Gesture</td>
<td>Narrative Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Expand</strong></td>
<td>Hands held slightly apart at chest height, palms facing together. Hands then moved apart until outside shoulder width.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Eye</strong></td>
<td>Index finger points towards one eye.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Back and forth</strong></td>
<td>Hands held shoulder width apart, palms facing in. Hands then moved to the right, and then to the left.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water bursting out of Donald's nose</strong></td>
<td>One hand held in a fist, moved towards the nose. Fingers then</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- “that the water station began to **expand**”
- “the water station began to **change shape**”
- “water began spurting out straight into Donald duck’s **eye**”
- “it kept moving **back and forth** out of Donald Duck’s reach”
- “he **chased it** with his bucket”
- “water burst out of his **nose**”
- “water burst out of **him**”

- What happened to the water station when Donald Duck was moving the lever up and down really fast?
- Where did the water squirt Donald Duck?
- What did the water keep doing when Donald Duck kept trying to fill up his bucket?
- Where did the water come out of Donald?
Duck’s nose spread out with palm facing upwards.

Pushed up One hand held to the side of the body at hip height, positioned with palm facing upwards and hand flat. Hand then rises upwards.

“water came blasting out which caused Donald Duck to get pushed up in the sky”

“water came blasting out which caused Donald Duck to get pushed”

Bucket broke Both hands held at chest height, shoulder width apart, with palms facing together, and fingers pointing upwards. Hands then tilt outwards such that palms begin to face upwards.

“As he went to get it, the bucket broke”

“As he went to get it, something happened to the bucket in the end?”

What happened to the bucket in the end?

Note. Gesture was produced on bolded component of phrase.
Table 1

Mean (and Standard Deviation) PPVT-4 standard scores and age by Gesture and Verbal Information Condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Verbal Information</th>
<th>No Gesture</th>
<th>Gesture</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPVT-4 Standard</td>
<td>Missing</td>
<td>105.62 (13.89)</td>
<td>102.68 (11.13)</td>
</tr>
<tr>
<td></td>
<td>No Missing</td>
<td>103.96 (8.96)</td>
<td>102.12 (10.41)</td>
</tr>
<tr>
<td>Age</td>
<td>Missing</td>
<td>21.53 (6.33)</td>
<td>20.67 (3.08)</td>
</tr>
<tr>
<td></td>
<td>No Missing</td>
<td>21.40 (3.92)</td>
<td>21.47 (5.73)</td>
</tr>
</tbody>
</table>

*Note.* Standard Deviations appear in parentheses.
### Table 2

*Crosstabulation of Gender, Gesture Condition, and Verbal Information Condition*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Gesture</th>
<th>No Gesture</th>
<th>Gesture</th>
<th>No Missing Information</th>
<th>Missing Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>14 (26.9%)</td>
<td>11 (20.4%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>38 (73.1%)</td>
<td>43 (79.6%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>12 (22.2%)</td>
<td>13 (25.0%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>42 (51.9%)</td>
<td>39 (48.1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Numbers in parentheses indicate column percentages. $p <.05.$
### Table 3

*Mean (and Standard Deviation) free recall and recall of non-gesture phrase scores by Gesture and Verbal Information Condition*

<table>
<thead>
<tr>
<th>Gesture Condition</th>
<th>Verbal Information</th>
<th>No Gesture</th>
<th>Gesture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Recall</td>
<td>Missing</td>
<td>14.69 (6.18)</td>
<td>16.46 (6.52)</td>
</tr>
<tr>
<td></td>
<td>No Missing</td>
<td>17.15 (6.43)</td>
<td>15.15 (5.25)</td>
</tr>
<tr>
<td>Recall of Non-Gesture</td>
<td>Missing</td>
<td>7.19 (1.44)</td>
<td>7.79 (1.85)</td>
</tr>
<tr>
<td>Phrases</td>
<td>No Missing</td>
<td>7.30 (1.85)</td>
<td>6.65 (2.13)</td>
</tr>
</tbody>
</table>

*Note.* Standard Deviations appear in parentheses.