Stories and gesture: Redundant and non-redundant gesture use in narrative comprehension

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Abstract

Teachers naturally produce hand gestures when they teach. While there is evidence for gesture effectiveness when teaching mathematics and conservation, there has been limited research investigating the role of co-speech gestures on narrative comprehension. Specifically, the redundancy of the gesture with the associated speech content has been underexplored in this area. This study investigated the role that iconic and deictic, redundant and non-redundant hand gestures had on children's comprehension.

The 129 3 to 5-year-old children who participated in the study watched a video of a narrated story. The narration was accompanied by either iconic, deictic or no gestures which were redundant or non-redundant to the story content. Participants were asked both a free recall and cued recall questions relevant to the narrative.

Observing gesture facilitated comprehension as measured by free recall but not cued recall. However, the interaction between gesture type and gesture redundancy was not significant. Although children's individual language levels were positively associated with recall, there was also no observed interaction between gesture type, gesture redundancy and language ability. Results were unable to conclusively support one mechanism for the facilitative effect of gesture, findings tentatively supported the dual coding theory, the interactive contribution hypothesis and the attentional hypothesis.

Statement of Candidature

I hereby confirm that all material contained in this project are my original authorship and ideas, except where the work of others has been acknowledged or referenced. I also confirm that the work has not been submitted for a higher degree to any other university or institution. The research project was approved by the Macquarie University Human Research Ethics Committee (Approval No. 5201700076).

Signed:

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Stories and gesture: Redundant and non-redundant gesture use in narrative comprehension

Language, in particular speech, is often characterised by pragmatic ambiguity, and subtle meanings or intentions (Kelly, 2001; Kirk, Pine, & Ryder, 2011). As a result, speech comprehension is aided by non-verbal communication cues (Kirk et al., 2011). Specifically, hand gestures are one form of nonverbal communication that have been identified as a crucial link between language and context (Kelly, 2001). Hand gestures are a ubiquitous aspect of speech, with many different forms of hand gestures occurring simultaneously with verbal utterances (Kelly, Barr, Church, & Lynch, 1999). Particularly, gestures undertake a heavier communicative burden when the co-occurring speech is ambiguous, hard to hear or absent (Church, Ayman-Nolley, & Mahootian, 2004).

Humans use gesture naturally when they speak and are often not aware they have done so (Ping & Goldin-Meadow, 2008). The term gesture is used to define any movement of the hands and arms people engage in while talking (Roth, 2001). Kendon (1994) identified four characteristics that can be used to define hand gestures independent of other hand movements. These include: 1) gestures begin and end from a position of rest; 2) gestures have a peak structure whose function is to denote the meaning of the movement; 3) this peak is preceded by a preparation movement and succeeded by a recovery movement to begin and return to a position of rest, thereby creating a clear beginning, middle and end; and 4) gestures are symmetrical, in that any action before and after the gesture’s peak is identical (Kendon, 1994). Specifically, gestures are spontaneous movements actioned while speaking and can often improve communication and create a rich mental representation for the listener (Goldin-Meadow, Kim, & Singer, 1999; Kirk et al., 2011; Ping & Goldin-Meadow, 2008; Wakefield & James, 2015). Two functions of gesture accompanying speech have been proposed in the literature, that is, whether gesture serves a beneficial function for the speaker and/or the listener (Krauss, 1998).

Function of Gesture

The current body of literature concerning co-speech gesture identifies two main functions of hand gestures. The first of these is that gestures provide cognitive support for the speaker, and the second is that gestures are produced for the benefit of the listener (Krauss, 1998). Support for the former is centred on the consistent finding that people gesture even when they know the listener cannot see their gestures (Alibali & Don, 2001; Alibali, Heath, & Myers, 2001; Krauss, 1998). This presence of gesture in the absence of a listener implies the gesture is being performed for the benefit of the speaker themselves. Hostetter and Alibali (2008) suggest that gesturing has two advantageous functions for the speaker: lexical access and visual packing, both within a simulated action framework. The lexical access hypothesis proposes that gestures serve to create cross-modal primes in order to aid retrieval of a 'hard-to-find' word, while the visual packing hypothesis proposes that gestures break larger images into smaller verbal fragments more suitable for speech (Hostetter & Alibali, 2008).

The alternate, although not necessarily contradictory, explanation for the function of gesture holds that gestures are created by the speaker for the benefit of the listener, to provide visual clarity for the verbal information provided (Kirk et al., 2011; Krauss, 1998). That is, gestures are used for external communication and are socially motivated. In a meta-analysis conducted by Hostetter (2011), it was found that across studies investigating gesture, listeners had better speech comprehension when verbal content co-occurred with gesture than when verbal content was presented alone, with 83% of studies reporting a positive effect size for this relationship. Research supporting this hypothesis has shown that when a listener is present, the speaker's gesture production rate is significantly higher than when the speaker is deprived of reciprocal visibility with the listener. This effect has been seen in both children (Alibali & Don, 2001) and adults (Alibali et al., 2001). Additionally, Beattie and Shovelton (1999) demonstrated that participants who both saw gesture and heard verbal content subsequently produced more accurate responses than those who received verbal information only. Gesture's advantageous function for the listener relies on the listener's ability to integrate information from both the verbal and visual communicative modalities (Sekine, Sowden, & Kita, 2015).

The human ability to comprehend a phrase using both verbal and visual modalities together is referred to as gesture-speech integration. Gesture-speech integration is defined as the listener's ability to unify information from both the speaker's gesture and their speech, resulting in the two modalities mutually constraining each other's meaning (Sekine et al., 2015). Sekine et al. (2015) suggest that between three and five years of age, the ability to comprehend language develops from reliance on a single modality to the ability to integrate or select from multiple factors. In addition, Kirk et al. (2011) propose that children's story (narrative) comprehension could be aided by the integration of mental imagery and the verbal content of the story. With this function of gesture as an aid to the listener in mind, the focus of the current study is on the role of distinct *types* of gesture for the listener, specifically for three to five-year-old children's narrative comprehension.

Gesture Classification

Gesture types are defined by both their visual appearance and their semantic relationship with the accompanying verbal content. McNeill (1992) developed a classification system based on gestures used by a narrator while storytelling. This system includes iconic, deictic, metaphoric and beat gestures. Concordantly, Cassell and McNeill (1991) found speakers produce these same four distinct types of gestures both while narrating a story and while participating in social conversation. Iconic gestures are gestures whose form captures meaning corresponding to the referent that is simultaneously produced in speech. In particular, iconic gestures have a perceptual association with the concrete object or action they represent (Beattie & Shovelton, 1999; Hostetter & Alibali, 2008; McNeil, Alibali, & Evans, 2000; McNeill, 1985, 1992; Ping & Goldin-Meadow, 2008; Roth, 2001). For example, an accompanying iconic gesture for “car” could depict two hands in fists held at the ten and two o’clock positions, turning left and right together as if driving a car. Iconic gestures have been described as highly communicative and universal in nature. Therefore, they are the most frequently used gesture type in social conversation and most often appear to aid story events (Cassell & McNeill, 1991).

Deictic gestures are pointing movements, typically engaging the pointer finger but also performed by an extendable body part, with the goal of pointing to a particular referent in the physical environment (Hostetter & Alibali, 2008; McNeill, 1992; Roth, 2001). Metaphoric gestures are visually similar to iconic gestures, however, they are semantically related to abstract sentences rather than depicting a concrete action or object (McNeill, 1985; Roth, 2001). McNeill (1992) describes metaphoric gestures as having a dual structure: they must have a concrete base with semantic relevance to an abstract concept, for example, two hands cupping together with the accompanying sentence, ‘I want to ask you something’.

Iconic, deictic and metaphoric gestures are all semantically related to their accompanying speech. That is, they all convey conceptually relevant information and are therefore referred to as “representational gestures”. Such gestures are thought to disambiguate and aid interpretation of a spoken message and are therefore of great benefit to the recipient of the spoken message (Church et al., 2004; Kelly et al., 1999; Thompson & Massaro, 1994). The final gesture type commonly identified in gesture research, and not included in the representational gesture category, are beat gestures. These are abstract visual indicators, with no discernible meaning and no conceptual or semantic relationship to the co-occurring speech (Alibali et al., 2001; McNeill, 1985, 1992). Beat gestures tend to provide temporal structure to verbal communication, most commonly through flicks or tapping motions (Roth, 2001). As beat gestures are produced at comparable rates regardless of the reciprocal visibility of the speaker and listener, it has been suggested that their function is to aid lexical retrieval, rather than to aid the listener's interpretation of the spoken message (Alibali et al., 2001).

Although to date there is limited research directly comparing all four types of gesture, a growing body of research has shown that the four different types of gestures, independently, are all commonly produced by teachers while presenting instructions to students and can be important for enhancing students' learning experience (Church et al., 2004; Goldin-Meadow et al., 1999; Ping & Goldin-Meadow, 2008; Singer & Goldin-Meadow, 2005; Wakefield & James, 2015). Through observation of three teachers over the course of three years, Flevares and Perry (2001) were able to investigate the frequency of representational gestures used during mathematics lessons. These authors found that teachers used spontaneous gestures simultaneously with speech more often than any other form of non-verbal learning support such as pictures, concrete objects and written symbols.

The value of using gestures while teaching has been demonstrated across educational domains, including mathematics instruction (Flevares & Perry, 2001; Goldin-Meadow et al., 1999; Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Singer & Goldin-Meadow, 2005), language comprehension (Church et al., 2004; Sekine et al., 2015; Theakston, Coates, & Holler, 2014; Thompson & Massaro, 1994), conservation problems (Kelly & Church, 1998; Ping &

Goldin-Meadow, 2008, 2010), and symmetry (Valenzeno, Alibali, & Klatzky, 2003). For example, both Ping and Goldin-Meadow (2008) and Church et al. (2004) found that children's improvement from pre-test to post-test was significantly better when they viewed lessons on conservation with gestures, than was the improvement of those children who viewed instruction consisting of speech alone. Similarly, when learning palindromes, Wakefield and James (2015) found children's ability to learn was significantly better when instructions consisted of gesture with speech as opposed to only hearing the speech. Finally, while teaching symmetry, Valenzeno et al. (2003) found children in speech and gesture conditions made significantly more correct judgements and more advanced explanations than children in a verbal only condition. In this way, it has been established that complementing verbal teaching instruction with gesture can potentially have an important benefit for learning in the classroom. Throughout the literature investigating the use of gesture in education, there is one important feature of gestures that has been shown to be an effective learning tool: the extent to which the gesture content overlaps with that of speech.

Gesture Redundancy

Of the research mentioned above, all investigated the value of gesture when the semantic content of the gesture corresponded directly with the semantic content of the verbal message. This matching of speech and gesture content is referred to as 'reinforcing' or 'redundant' gestures (Hostetter, 2011; McNeil et al., 2000; Wakefield & James, 2015). Valenzeno et al. (2003) promote the value of using redundant gestures in teaching, in that the student is then provided with two different modalities through which to interpret the same message. That is, students' comprehension improved because the opportunity to understand the spoken message was doubled. In their analysis of teachers' use of gesture in mathematical instruction, Flevares and Perry (2001) found that teachers' use of gesture was most effective for students' comprehension when the two modalities were presented in a coherent manner.

There has however also been support in the gesture literature for the educational advantage of using non-redundant or 'mismatching' gestures in teaching mathematics and language (Goldin-Meadow et al., 1999; Hostetter, 2011; Wakefield & James, 2015). Gesture non-redundancy refers to gesture supplementing speech, in that the gesture either provides further clarity by providing supplementary information to the spoken message, or supplies the listener with an alternate explanation/semantic description with which they are likely to come to the same conclusion (Church et al., 2004; Thompson & Massaro, 1994). In a meta-analysis conducted by Hostetter (2011), studies investigating the communicative advantage of non-redundant gestures found effect sizes twice as large as those investigating redundant gestures.

However, in Hostetter's (2011) findings, the redundancy of the gesture was based on what the listener was supposed to be learning (i.e., there is a triangle) not the semantic content of the speech (i.e., a large triangle standing upwards), therefore the concept of gesture redundancy requires further investigation. Singer and Goldin-Meadow (2005), through an investigation of the mismatch between gesture and speech, concluded that the presence of a redundant gesture did not improve understanding for the student. Rather, only those presented with a mismatch between speech and gesture demonstrated improved post-test performance. Contrastingly, however, McNeil et al. (2000) compared the redundancy of the verbal message and the complexity of the message itself when examining referential communication with preschool children. Results showed that reinforcing gestures facilitated children's performance on the tasks, while conflicting gestures had no influence on children's comprehension. Across these studies, the effects of non-redundant gestures are contradictory and requires further investigation.

The relative benefits of using redundant or non-redundant gestures while teaching is as yet unclear. There is ample evidence in the literature indicating the benefits of both redundant and non-redundant gestures in educational settings. For example, Wakefield and James (2015) found no difference in effectiveness between reinforcing deictic gestures and mismatched deictic gestures when teaching children palindromes; both were equally effective. To our knowledge, there has not yet been a thorough investigation comparing gesture redundancy across different gesture types. Therefore, no conclusion can be drawn regarding under which circumstances different gesture presentations might be more or less effective. This comparison is the focus of investigation in the present study.

Considering the gesture redundancy platform on which the current study is based, beat gestures are not included, as they are, by nature, non-redundant to any corresponding spoken content. Additionally, as mentioned previously, the age group of interest in this investigation is children aged 3- to 5-years old, as this is the developmental stage at which children start to develop skills in speech-gesture integration (Sekine et al., 2015). This is also the age at which learning from narratives is most important for development (Kirk et al., 2011). As metaphoric gestures may be too cognitively challenging for preschool-aged children, such gestures will also be excluded from the current study. The current investigation therefore focuses on iconic and deictic gestures (referred to as ‘representational gestures’), and the role of redundancy within these gesture types in the context of learning from a narrative.

Gestures in the Classroom

There is ample evidence to suggest that the use of hand gestures in the classroom is the most common form of non-verbal representation used when accompanying speech by teachers (Flevares & Perry, 2001). Consequently, this investigation will only focus on hand gestures, and not on other forms of non-verbal representation. Goldin-Meadow et al. (1999) and Corts and Pollio (1999) propose two ways gesture can be of benefit in an educational context: 1) revealing the knowledge and attitudes of the student and 2) providing clarification into the content of the lesson itself. As this study is investigating teachers' use of gesture, we will focus on the latter.

Although there has only been one study to date providing a direct comparison between the different gesture types in the context of narrative comprehension (Macoun & Sweller, 2016), there is consistent support for the teaching value of iconic and deictic gestures independently. For example, as noted above, Ping and Goldin-Meadow (2008) found iconic gestures had a powerful influence when teaching conservation to young children, with performance from pre-test to post-test improving significantly more when instruction consisted of speech and gesture compared to speech alone. This result was found regardless of whether the object that was the speech referent was physically present or absent for the listener, indicating that iconic gestures are effective communicative tools independent of other visual representations.

Iconic gestures may be most beneficial for specific semantic categories. Beattie and Shovelton (1999) investigated narrative comprehension and found iconic gestures resulted in significantly greater post-test performance when the gesture represented relative position or size of a concrete object. Demir, Fisher, Goldin-Meadow, and Levine (2014) also investigated narrative comprehension, and found not only that children benefited from the accompanying iconic gestures when presented with a cartoon story, but were also more likely to use iconic gestures when describing the story to the experimenter after viewing it. In this way, iconic gestures are clearly influencing the listener's semantic interpretation of the narrative presented.

Deictic gestures have also been thoroughly investigated in the educational domain as effective nonverbal learning supports and are the most commonly used gesture type by teachers

(Alibali, Sylvan, Fujimori, & Kawanaka, 1997). In particular, pointing gestures have been shown repeatedly to have a powerful impact on children's ability to learn mathematics. For example, Goldin-Meadow et al. (1999) found that when teachers used pointing gestures to explain strategies for solving mathematical problems, students applied the teacher's strategy significantly more frequently than those who were presented with verbal instruction alone. Singer and Goldin-Meadow (2005) replicated this finding, concluding that deictic gestures were particularly beneficial for the student when the teacher presented alternate strategies in the verbal and gestural modalities, providing children with two unique ways to solve the addition problem.

The role of language ability. The relative effectiveness of deictic and iconic gestures for learning has been thoroughly investigated, and these results have been shown to be dependent, to some extent, on the learner's language ability. With reference to iconic gestures, studies comparing children with specific language impairment (SLI), and therefore low language ability, have consistently found children with SLI perform significantly better on post-test questions when verbal instruction was accompanied by iconic gestures than when verbal instruction is presented alone (Kirk et al., 2011; Mainela-Arnold, Alibali, Hostetter, & Evans, 2014). Kelly (2001) conducted a study in which children were required to use information provided to them in both speech and gestures in order to comprehend the intention of an ambiguous verbal phrase. This study found an interaction between age and condition, in that younger children had a significant difference between those who viewed co-speech gesture and those who didn't, while older children showed no effect of gesture. The authors concluded this was due to the younger children having difficulty comprehending the verbal part of the task while older children did not have this difficulty. However, this effect was only evident when children were required to respond to the request, not when they were passive observers viewing someone else responding to the request.

Contrastingly, deictic gestures do not possess semantic properties on their own, independent of verbal content, therefore it has been suggested that their presence may be more beneficial for children high on language ability than for children with low language ability. Wakefield and James (2015), when teaching primary school children palindromes, found deictic gestures only aided learning in children high on language ability. Concordantly, Thompson and Massaro (1994) found that preschool students benefited less from the addition of deictic gestures beyond speech alone than did fourth-grade students. Therefore, it is evident iconic and deictic gestures differentially affect learning depending on the child's language ability. Iconic gestures, whose form can be entirely interpreted independent of speech, have been shown to be more positively influential for children low on measures of language skill. In opposition to this, however, deictic gestures which are often used to indicate what aspect of the physical environment is being referred to in speech, have been shown to be more effective in supporting the comprehension of children high on measures of language ability.

Due to the potential influence language ability may have on the effectiveness of gesture as a non-verbal learning support, language ability is included in the current study. The inclusion of language ability is of particular importance due to the fact that the effect of gesture on language ability has had mixed results in previous studies as evidenced above.

Although it has been established that gesture, overall, can have a valuable effect on learning, the difference in the relative usefulness of each gesture type emphasises the need to understand what mechanisms might drive the beneficial effects of gesture in the classroom. The facilitative effect of observing gesture in the classroom can be explained by four possible mechanisms: dual coding, interactive contribution, cognitive load reduction, and attention. These mechanisms are not mutually exclusive explanations, rather, describe varying accounts of the benefits of gestures.

Mechanisms Accounting for *Why* Gestures are Beneficial in the Classroom

Dual coding theory. Speech and co-occurring gestures may interact to create a richer mental representation than the presentation of speech alone (Kelly et al., 1999). Clark and Paivio (1991) proposed the dual coding theory of mental imagery, emphasising the importance of both the verbal and nonverbal communication systems when presenting information. According to the dual coding explanation, simultaneous presentation of visual imagery and verbal utterances has an additive effect, which creates a superior mental representation beyond the verbal information alone. The dual coding theory emphasises the role of spreading activation. That is, providing instruction in both the verbal and visual modalities creates highly active representations that are likely to activate semantically associated nodes in the neural network. In this way, information is more efficiently retrieved, thereby providing the learner with greater opportunity to recall information compared to content presented in only one modality (Hostetter & Alibali, 2008).

In a large review, Hostetter (2011) found that hand gestures provide a unique communicative benefit to the listener, beyond the value of viewing the face and mouth movements of the speaker. Hostetter and Alibali (2008) suggest gesture’s effectiveness as the nonverbal modality in a dual coding explanation, superior to face and mouth movements, is grounded in the link gestures provide between perception and action. That is, gestures simultaneously activate the mental imagery and language processing systems needed to stimulate working memory, lexical retrieval and visualisation, as well as creating a link between language and concrete objects, absent concrete objects and abstract objects or events (Hostetter & Alibali, 2008). These authors suggest this explains why gestures more often occur simultaneously with speech about physical or spatial information than non-spatial information. For example, a meta-analysis found that the communicative effects of gestures accompanying spatial and motor topics significantly superseded that of gestures accompanying abstract topics (Hostetter, 2011).

Interactive contribution. While the dual coding theory provides a credible explanation for the advantage of presenting complementary information in the visual and verbal modalities, the theory neglects to consider that, for most listeners, verbal content is accessible, and thus, gesture is unnecessary. That is, if the redundancy between the two modalities is high, listeners with adequate language ability need only access one modality to retrieve the relevant information. Kelly (2001) asserts that realistically, language comprehension is plagued with ambiguity. In particular, children are often expected to rely on nonverbal forms of communication to interpret pragmatic ambiguity in speech. For example, "*it's almost dinner time"* could simply be a statement of temporal fact, or could implicitly indicate to the child that it is time to pack toys away in preparation for dinner. Thus, a second potential mechanism for gesture's effectiveness in the classroom could be that gesture provides supplementary semantic information in order to provide clarity to the intention of the verbal utterance.

As Clark and Paivio (1991) focused on the additive effects of the verbal and nonverbal modalities to relay information and support learning, Kelly et al. (1999) suggest a more relevant model would be one of semantic integration or interactive contribution. The latter suggests that, when the redundancy of the two presenting modalities is low, gesture and speech do not strictly contribute to meaning in an additive fashion, but rather interact to contribute to meaning. That is, the relative activation of the verbal and nonverbal systems mutually constrain each other to create a rich semantic representation of an object or event (Kelly et al., 1999). In this way, learning is enhanced as ambiguous verbal statements interact with gesture to create specificity in the information provided.

Consequently, Kelly et al. (1999) investigated the credibility of an interactive contribution model, in opposition to the dual coding theory of additive contribution. These authors examined the role of deictic gestures in elucidating to the listener the intentions underlying indirect requests such as *"it's getting hot in here"* (while pointing at the window). In this case, the intention is to open the window. As the referent in the vignettes was determined by a combination of gesture and speech, the study found that university students were significantly better at producing the correct action response when both modalities were presented, compared to speech or gesture alone, thereby providing support for the interactive contribution model. Kelly (2001) further consolidated the model in children, with 4- and 5-year old participants producing more intended action responses when presented with both gesture and speech compared to speech alone. This model may explain why many studies fail to find a large effect size when investigating the effectiveness of redundant gestures on comprehension (Hostetter, 2011). The facilitative effect of gesture, therefore, may be accounted for by the interaction between speech and gesture when gesture supplements, rather than just complements, speech.

Cognitive load reduction. An alternate mechanism that may contribute to the facilitative effect of gesture in the classroom is by reducing cognitive load (Goldin-Meadow et al., 2001). Gestures have been shown to be effective learning tools in this way both for the speaker and the listener. For the former, Ping and Goldin-Meadow (2010) found that participants who used gestures to explain the concept of conservation performed significantly better on a concurrent secondary memory task than those who were instructed not to gesture during their explanation. Concordantly, Goldin-Meadow et al. (2001) examined this phenomenon in both children and adults, requiring participants to remember a brief list of words while explaining how to solve a mathematical problem. Results from this study showed that all participants, regardless of age, remembered a significantly larger number of items from the word list if they gestured during their explanation than if they did not gesture. As gesturing is a natural and spontaneous behaviour participated in while speaking, it may be possible that instructing a speaker not to gesture during an explanation is increasing their cognitive load by giving them another task to think about. When the authors then looked at those who could have gestured but didn't compared to the times they did gesture, however, using gestures during an explanation still reduced cognitive load for the speaker and allowed them to remember more words (Goldin-Meadow et al., 2001). Finally, Chu, Meyer, Foulkes, and Kita (2014) examined the relationship between gesture use by a speaker and their cognitive abilities. These authors found a negative relationship between cognitive abilities and the frequency of use of representational gestures by the speaker, concluding that those with poorer cognitive performance used more gestures when speaking compared to those who performed well on cognitive tasks. This finding suggests using gestures may be less cognitively demanding than communicating with speech alone, and contributes to the cognitive load reduction hypothesis for the function of gesture.

Gestures have also been shown to reduce cognitive load for the listener, providing an easier opportunity to learn what is being taught (Wakefield & James, 2015). Hand gesturing can result in the listener's eye saccades being directed to either the object of the verbal utterance or the space in which the object should be, thus providing the listener with a motoric or spatial link between the speech and its referent, and making speech comprehension easier (Ouwehand, van Gog, & Paas, 2015; Ping & Goldin-Meadow, 2010). Ping and Goldin-Meadow (2010) also propose that, as gestures provide a form of communication in a different modality to speech, that listeners can use gestures to organise aspects of the speaker's verbal instruction by chunking mental images. For example, McNeil et al. (2000) conducted a study comparing preschool children's comprehension of a spoken message, accompanied by either deictic or iconic gestures. Results of this study showed that redundant gestures were able to improve children's comprehension of complex spoken messages. The gestures however had no effect on the comprehension of simple spoken messages. This finding demonstrates that viewing co-speech gestures was able to make the cognitive complexity of the spoken message easier for the listener to comprehend.

Further, children with SLI have a cognitive impairment in their language system and there has been consistent support in the literature for the role of gestures in effectively improving these children's comprehension, beyond that of speech alone, and produces similar performance in these children when compared with typically developing children (Kirk et al., 2011; Mainela-Arnold et al., 2014; Vogt & Kauschke, 2017). This result suggests that gesture presented with speech is less cognitively demanding to process than speech alone for those with lower language ability and provides support for the hypothesis that the presence of co-speech gesture reduces cognitive load for the listener.

Attention. Finally, it has been suggested that the semantic nature of the gesture may not be relevant to learning at all, but rather, that the presence of any hand movement itself might facilitate comprehension by drawing the learner's attention to the verbal content (Theakston et al., 2014). The aforementioned research has primarily focused on the use of representational gestures in the classroom. However, the role of non-representational gestures, such as beat gestures, has been under-investigated. As beat gestures lack semantic relevance to the accompanying verbal content, their effectiveness in teaching cannot be attributed to the previously mentioned mechanisms. It has been speculated in past research that the gesture itself, as an action, could possess an attentional mechanism, and therefore, beat gestures may have an advantageous effect on recall and comprehension (Ravizza, 2003).

For example, Theakston et al. (2014) found non-representational gestures were able to improve participants' comprehension compared to that of those who did not view gesture. This finding suggests teachers are able to maintain students' attention through merely the presence of gesture and therefore facilitate comprehension. This finding corresponds with that from Valenzeno et al. (2003), who found children turned their heads away from a symmetry lesson significantly more frequently during the verbal-only lesson than the verbal plus gesture lesson.

Throughout the literature reviewed to this point, there has been an important focus on the facilitative advantage of accompanying speech with gestures in order to aid comprehension. Gesture has been shown to be effective in improving comprehension in adults (Alibali et al., 2001; Holler, Shovelton, & Beattie, 2009), in children (Kelly, 2001), in those with language impairment (Demir et al., 2014; Kirk et al., 2011; Mainela-Arnold et al., 2014) and in non-native English speakers (Church et al., 2004) across the domains of palindromes (Wakefield & James, 2015), language development (Sekine et al., 2015; Theakston et al., 2014), and cartoon comprehension (Alibali & Don, 2001; Beattie & Shovelton, 1999). Of this literature, predominant focus has been on the comprehension of task instructions or explanation of a concept. There has been a relative lack of investigation into the role of gestures for children's narrative comprehension.

Narrative Comprehension and Gesture

To learn from narratives and storytelling is crucial for children's language development (Demir et al., 2014), abstract thinking (Egan, 1993), reading comprehension (Dickinson & Tabors, 2001) and school achievement (Paris & Paris, 2003). In particular, Egan (1993) asserts that younger children experience difficulty understanding a concept unless it is embedded in a narrative or story they can relate to. For example, younger children struggle to comprehend Piaget's mountain task as they cannot understand perspective taking. However, if the task is accompanied by a story in which different characters view different perspectives, the concept is much more accessible. Additionally, narratives provide children with a stark contrast between common abstract binary concepts, such as good and evil, love and hate, anxiety and security, and therefore provide an opportunity for children to relate what they are learning to their own experiences (Egan, 1993).

Although narrative comprehension has been explored in past gesture research (Alibali et al., 2001; Demir et al., 2014; Holler et al., 2009), only one study has successfully compared the effects of observing both iconic and deictic gestures in children. Macoun and Sweller (2016) presented pre-schoolers with a video of a verbally narrated story, accompanied by either deictic gestures, iconic gestures, beat gestures or no gesture. The children were then asked one free recall question regarding what they remembered from the story, as well as 15 specific questions with forced choice alterative answers. Of these 15 questions, ten corresponded with the phrases presented simultaneously with gesture during the narrative, and five corresponded to items that were not accompanied by any gestures. The results showed that children who viewed the iconic or deictic gesture condition videos performed significantly better on the free recall question than those in the beat gesture or no gesture conditions. This result was then mirrored for the specific questions, with children in the iconic or deictic gesture conditions performing significantly better than children in the beat gesture or no gesture conditions. However, there was no difference between the effects of iconic and deictic gestures.

The 2016 study did also include gestures which were either redundant or non-redundant with the accompanying verbal phrase. That is, some gestures contained no information that was not already presented verbally by the narrator (redundant gestures), while some gestures provided additional information not present in the speech (non-redundant gestures). However, this gesture manipulation was conducted within subjects. Of the ten phrases presented with gesture, half were accompanied by redundant gestures and half were accompanied by non-redundant gestures. As no counterbalancing of which particular phrases were accompanied by redundant or non-redundant questions was conducted between participants, the authors were unable to adequately control the difficulty of each set of questions/gesture items. The redundant/non-redundant manipulation was confounded by item difficulty. As a result, the authors were unable to accurately compare the effects of redundant vs non-redundant gestures. The current study aims to address this confound by comparing gesture redundancy between (rather than within) subjects. In this way, all gesture items are included in each condition and can be more accurately compared.

Considering the results from Macoun and Sweller (2016) and the importance of narrative comprehension for younger children's development, the current study investigates the facilitative effects of iconic and deictic gestures, and their respective redundancy, on pre-schoolers' narrative comprehension. Pre-schoolers viewed verbal narratives accompanied by either iconic or deictic gestures, or by no gesture. Half the participants saw redundant gestures, which overlapped completely with the speech content. The other half saw non-redundant gestures, in which the gestures were identical to those in the redundant conditions, however the speech content was incomplete, meaning the gestures presented new non-redundant information. For all participants, the verbal narrative was presented with an accompanying visual display, which contained the items mentioned in the narrative. Participants' verbal and gestural recall was measured.

Aims and Hypotheses

Existing research has repeatedly demonstrated the beneficial effects of iconic and deictic gestures in the classroom (Hostetter, 2011). Macoun and Sweller (2016) found both iconic and deictic gestures to be of benefit for narrative comprehension compared to no gesture, however there was no difference observed between the two gesture types. Therefore, the current investigation aimed, firstly, to support the importance of iconic and deictic gestures for children's narrative comprehension. It was hypothesised that iconic and deictic gestures would improve children's narrative recall when compared with no gesture, however, the two types of gesture would not differentially affect children's narrative recall performance.

A main effect of redundancy was expected, such that participants in the redundant conditions would perform better at recall than participants in the non-redundant conditions. This effect is expected primarily due to participants in the control conditions, who saw no gestures. Although children in the non-redundant control condition saw items relevant to the narrative in the visual display, they did not receive any verbal or gestural information regarding these items. As a result, performance should be superior in the redundant condition, in which children saw items in the display and heard them referenced in the verbal narrative. This main effect is not of primary interest to the current study. The main effect of interest is the interaction between redundancy and gesture condition.

There is debate in the current gesture literature regarding the value of redundant and non-redundant gestures in an educational context. A lack of evidence exists directly comparing the beneficial effects of redundant and non-redundant gestures in children. Therefore, the current investigation aimed to explore the role of redundant and non-redundant gestures in children's narrative comprehension. It was hypothesised that non-redundant gestures would be significantly more beneficial for narrative recall than redundant gestures. Specifically, an interaction between gesture type and gesture redundancy was expected, such that the beneficial effects of observing iconic and deictic gestures compared to no gesture was expected to be larger in the non-redundant condition than the redundant condition. This hypothesis stems from the lack of large effect sizes in previous literature investigating redundant gestures as non-verbal learning supports (Hostetter, 2011), likely due to the redundant nature of these gestures. Furthermore, given that children are able to detect information independently portrayed in a speaker's gesture (Thompson & Massaro, 1994), it is expected that supplementary (non-redundant) information will aid recall through the gesture itself in the iconic condition and through reference to the visual display in the deictic condition, as well as supporting the verbal information. This result would provide support for the interactive contribution model. Confirmation of this hypothesis would indicate that children are integrating the verbal content with the supplementary information they are receiving from the non-redundant gesture.

Finally, it is clear from past literature that language ability differentially impacts the effectiveness of deictic gestures as non-verbal learning supports. However, this relationship is more unclear in regard to iconic gestures and therefore warrants exploration. Both a main effect of language ability and an interaction between language ability and gesture condition were expected. First, it was hypothesised that language ability would positively predict narrative comprehension above and beyond gesture condition. Secondly, it was expected that those with lower language ability would benefit more from the presence of gestures than those with higher language ability. Due to the suggestion that the effectiveness of observing deictic gestures is more susceptible to the listener's language ability than other forms of gesture (Singer & Goldin-Meadow, 2005; Thompson & Massaro, 1994), the interaction between gesture type and language ability will be investigated. Specifically, was hypothesised that the comprehension difference between low and high language abilities would be greater for participants who viewed deictic gestures than those who viewed iconic gestures.

Although the relationship between language ability and gesture redundancy has not yet been thoroughly explored in previous literature, there is justification for investigating this relationship. Through examining the beneficial effects of redundant or non-redundant gestures in teaching children palindromes, Wakefield and James (2015) suggested that when gesture and speech match, this increases the amount of working memory a listener can dedicate to processing the presented information and thus, decreases cognitive load. This implies that those children with low language processing skills might benefit more from viewing redundant gesture than non-redundant gesture compared to children with high language ability. Therefore, it is hypothesised that an interaction between gesture redundancy and language ability might exist, such that children with lower language ability might benefit more from viewing redundant gestures than non-redundant gestures when compared with children with higher language ability. Considering an interaction between language ability and gesture type and an interaction between language ability and gesture redundancy is expected, it is hypothesised that a three-way interaction might be significant.

A three-way relationship here was explored based on the findings by McNeil et al. (2000). These authors tested children's comprehension and found younger children benefited more from viewing redundant gestures compared to no gestures than did older children. Even when the gestures conflicted with the speech, older children relied more on the spoken message while the younger children performed poorly when the two modalities contradicted each other. This would suggest that those with poorer language comprehension rely more on complimentary information portrayed in both speech and gesture rather than speech alone or conflicting information compared to those who have more superior language ability. Therefore, it was hypothesised that the comprehension difference between participants with low and high language ability when viewing iconic and deictic gestures compared with no gesture might be superior for those viewing redundant gestures compared with non-redundant gestures.

Considering the assumption put forward by Wakefield and James (2015), a significant interaction between language ability and gesture type; language ability and gesture redundancy and a significant three-way interaction would lend support to the gesture function theory of cognitive load reduction. If the presence of gesture was to improve performance in those with low language ability, this would suggest that gestures are reducing the cognitive load on the listeners' working memory system, thus resulting in easier processing of the presented language.

It should be noted that all of these expected effects were only anticipated for performance on aspects of the narrative that were associated with gestures. Gestures were not expected to have an effect on performance on items in the narrative that had no associated gestures for participants in any condition. There were not expected to be any main effects or interactions of gesture condition or gesture redundancy for items in the narrative that had no associated gestures.

Method

Experimental Design

The current study was a 3 (iconic/deictic/control) x 2(redundant/non-redundant) between subjects design. Participants were randomly allocated to one of the six conditions: redundant/deictic (*n*=22), redundant/iconic (*n*=22), redundant/control (*n*=21), non-redundant/deictic (*n*=21), non-redundant/iconic (*n*=22) and non-redundant/control (*n*=21). The dependant variable of interest was narrative recall, with higher scores indicating better narrative comprehension. Narrative recall was operationalised in terms of both free recall and answers to specific questions about the narrative (cued recall, detailed below). The independent variables of interest were gesture condition (iconic/deictic/control), gesture/spoken message redundancy (redundant/non-redundant) and receptive language ability as measured by the Peabody Picture Vocabulary Test (Dunn & Dunn, 2007).

Participants

The participant sample in this study consisted of 134 preschool children aged 3.00-5.92 years old (*M* = 4.39, *SD* = 0.66). The sample comprised of 64 male (48%) and 70 female (52%) children. Participants were recruited from independent preschools in the Sydney metropolitan area. Initial contact was with the preschool directors (see Appendix A for the Director Information Form). This was subsequently followed by written parental consent and verbal child consent prior to commencing the child's participation (see Appendix B for a copy of the Parental Information and Consent Form). In order to be eligible for the study, children were required to be fluent in English and typically developing. Five children were omitted from the study. Three children did not answer all questions, one child's responses were not filmed due to technological error and one child's Autism Spectrum disorder diagnosis was disclosed only after testing. The final sample consisted of 129 children.

Materials

Stimulus video. The primary stimulus in the experiment was a narrative describing a girl's afternoon at the park and evening at home with her family. The narrative was derived from that used in a previous investigation (Macoun & Sweller, 2016). It was adapted in order to suit the current study's objectives. A male narrator unknown to participants was filmed narrating the story using a video camera (audio and visual). In the video, to ensure consistency between conditions, the narrator was seated in front of a plain white wall, wearing a white t-shirt. Directly in front of the narrator there was a visual display of children's toys simulating a children's playground and family home, including items both complementary (redundant) and supplementary (non-redundant) to the narrative (see Figure 1 for the visual display). The items were required for reference in the deictic condition, however they remained present in all conditions to maintain consistency of presentation.

Figure 1. Visual display of the playground and family home.

Each of the six conditions was filmed separately and consisted of the verbal narrative with the corresponding gestural actions. Each participant viewed one video only. In the three redundant conditions, the verbal content of the story explicitly revealed aspects of the narrative, for example, ‘Daisy played on the swings, going back and forth, back and forth’. Conversely, the verbal content non-redundant videos did not explicitly indicate the reference point, for example, ‘Daisy ran to play on the playground, going back and forth, back and forth’. These phrases were accompanied by gestures in four of the conditions (all conditions excluding the control conditions). The control conditions contained the redundant or non-redundant verbal narrative content with no accompanying gesture.

Gestures occurred at ten points throughout the narrative (at the same point of the verbal content each time) and were either iconic or deictic in nature, depending on the condition. For example, in the phrase associated with Daisy playing on the swing, the iconic gesture was a mime swinging the hands back and forth in the air. In the deictic condition, the corresponding gesture was a direct point to the toy swing set on the table in front of the narrator. The form of the gesture was the same between the redundant and non-redundant conditions for each of the iconic and deictic conditions. A copy of the story script and the accompanying gestures for each condition is in Appendix C.

Filler task. After the participant viewed the video, a filler task was provided for them to complete. This consisted of a join-the-dots task which took around 3 minutes to complete. Children were offered help in its completion. The primary purpose of this task was to reduce the likelihood of any improved recall for any specific part of the narrative due to primacy or recency effects. Although unlikely in this age group, this filler task also reduces the probability of any rehearsal effects of any aspect of the narrative. A copy of the join-the-dots filler task can be found in Appendix D.

Response items. Following the filler task, each participant was asked a series of questions regarding the narrative. First it was explained to the child that the questions would be regarding the story and if they don't know the answer they should guess. Every child was first asked a single free recall question regarding what they remember from the story. Following this, each child was asked 15 specific questions about the narrative. The order of these questions was randomised separately for each child to prevent order effects, using a random number generator.

The bank of specific questions consisted of ten questions that related to points in the narrative that were accompanied by a gesture for the iconic and deictic conditions, and five questions that related to points that did not have an accompanying gesture in any condition. Wording of all questions remained the same across conditions. The five non-gesture items were used to test general story content comprehension and the ten specifically gesture-related questions were used to indicate comprehension of speech with accompanying gestural information.

Participants were first offered an opportunity to freely answer the question presented. If the child was unable to recall the answer or provided the experimenter with the incorrect answer, the child was present with a forced choice alternative. For example, if the child answered 'koala' to "what type of animal did the family see on the way home?", then the forced choice alternative offered to the child was "dog or bird". The order of presentation of these alternatives was counterbalanced across participants to further prevent order effects. Two forms of the questionnaire were created. Half of the participants received "dog or bird" and the other received "bird or dog". In addition, half the questions within each predetermined set of questions had the correct answer first. Coding and scoring of responses are described below.

Similarly to Macoun and Sweller (2016), the presence of the visual stimuli in all videos had to be taken into account as it could influence a child's response to the questions. Therefore, for the gestural questions, half of the forced choice alternatives were both in the visual scene and for half the questions only one of the alternatives was included in the visual scene. For example, for the question "what did Daisy's mum do when the family arrived home?", the accompanying alternatives are "go upstairs or cook dinner". In this case the visual display contained both a set of stairs leading upwards and a kitchen. However, for the question "after Daisy's dad carried her to her room, what did he do?", the accompanying alternatives are "tuck her into bed or play with her and her soft toys". In this case, there is a bed in the visual display but no soft toys. This was a compromise decided upon as the visual display became too crowded with all items present, but equally some forced choice options had to be present for the deictic gesture conditions. Importantly, the visual display was not available to the participants during recall, only while viewing the narrative. A copy of the questions presented to participants is available in Appendix E.

Peabody Picture Vocabulary Test-4. After completing the narrative questionnaire, the Peabody Picture Vocabulary Test-4 Form A (PPVT-4, Dunn & Dunn, 2007) was administered to each child. This was done to measure receptive vocabulary and consequently a) determine if the child was able to comprehend the narrative presented and b) use test scores as a predictor in analyses. The test items consist of four pictures in multiple-choice format. The participant is shown one item at a time and verbally presented with a word. The child then needs to indicate with a pointed finger which image is the semantic match to the verbally presented word. For example, one page may have three distractors and one picture of a fish and the experiment says to the child, ‘point to the fish’ and the child is scored as either correct or incorrect for that item, depending on which picture they point to. Testing is ceased when the child gets eight errors in a set of 12. From children’s final score an age equivalent was determined. The PPVT-4 was used, in this case, to discern a child’s receptive language ability because accurate story comprehension requires adequate knowledge of word meaning (Becker, 1977). Consequently, children with an age equivalent score of younger than three years old were to be eliminated from the study, as it would not be clear whether they had the receptive language ability to understand the story. In this sample, no children scored below 3 years old on receptive language ability. The PPVT-4 has internal consistency of .94, test-retest reliability of .93 and a parallel-forms reliability of .89. Further, the test has convergent validity between .68 and .82 (Dunn & Dunn, 2007).

Procedure

Prior to commencement, the Macquarie University Faculty of Human Sciences Human Research Ethics Sub-Committee approved the study (Reference Code: 5201700076). Following ethics approval, preschool directors were contacted by phone and asked if they would be interested in supporting the experiment. Those who provided verbal agreement were then provided with the Director Information Sheet and the Participant Information Statement and Consent Forms. Once the director was familiar with the study and agreed to the preschool’s participation, the information and consent forms were distributed to parents. Only those children who returned signed consent forms were able to participate. In addition, verbal consent was sought from each child before the child participated. All children verbally consented to participate.

Each participant was tested individually in a quiet area of their preschool classroom. The quiet nature of the testing area was crucial for the video camera to pick up all of the child's answers to the questions. Additional verbal consent from the child was obtained before starting particular parts of the experiment, in particular, the presence of the video camera was explained to the child and the child was asked if filming was okay for them. All agreed to be filmed. Once rapport was established with the child, the video narrative was played. First, the experimenter instructed the child to pay close attention to the video as they would be asked questions about it afterwards. Then the appropriate video for the child's condition was switched on. These were randomly allocated, with each child viewing only one of the six videos.

Following the video presentation, the child was asked to do the dot-to-dot filler task. Some children had done these tasks before and were happy to complete it independently. Other children were not familiar with the task and so were presented with instructions regarding drawing around the dots in numerical order. Those who needed extra help completed the task with the experimenter guiding the pen around the image while they counted together. This took around two to four minutes to complete.

Once the filler task was complete, the experimenter asked the child the story-related questions according to the pre-established interview protocol. This started with the phrase "I am going to ask you some questions about the story you saw on the computer. If you don't know the answers you can just guess, okay?". Then the free recall question was always asked first, "First, please tell me everything you remember about the story you saw on the computer". This was followed by the 15 specific questions in a randomised order. If the child appeared confused or inattentive, the question was repeated. Non-directional but positive encouragement was given throughout the interview. If the child's answer was wrong, the experimented gave a general positive comment such as “okay great” and then presented the child with the forced choice alternative for that question. Children were not told explicitly they had incorrectly answered a question to ensure they remained confident in their answers throughout the interview.

At the conclusion of the questions, the video camera was switched off. It was not necessary to record the PPVT-4 administration. The experimenter then explained the PPVT-4 instructions to the child and the child’s starting point was determined based on their chronological age. The child’s performance was recorded on the PPVT-4 score sheets. If the child failed to answer any question, this was marked as a ‘don’t know’ response and counted as an error. Higher scores indicated greater receptive language ability. The child was then given the opportunity to pick a sticker from a book as a reward and taken back to their class.

Coding

The entirety of the interaction between the experimenter and the child was transcribed from the videos and responses to the questions were coded. This transcription included any gesture the child made in response to a question as well as their verbal response. For the free recall question, any aspect of the story the child was able to recall accurately was scored with a 1. Higher scores indicated greater comprehension of the narrative. The maximum score a child could receive for free recall was 35 and there was no negative scoring.

For the specific questions, a maximum of 2 points per question could be received. If the child was able to answer the open-ended question, this resulted in a score of 2 and they were not presented with the forced choice alternative. If the child’s initial response to the open-ended question was incorrect, they did not answer or said, ‘I don’t know’, the forced choice alternative was presented. If the child gave the correct answer after having heard the forced choice alternative, the participant received a score of 1. If a non-response or incorrect responses was given following the forced choice options, the participant received a score of 0. These scores were separated into non-gesture items and gesture items. The maximum scores for the two sets of items were 10 and 20 respectively, corresponding to the five non-gesture items and 10 gesture items. Higher scores indicated greater narrative comprehension.

Reliability

Inter-rater reliability was established with a second, independent rater. The second rater was blind to the aims of the study and coded 20% of the transcripts. Reliability was analysed by obtaining single-rater intraclass correlations (*ICC's*) with an absolute agreement model. These were highly significant for all dependent variables. Free recall had an intraclass correlation of .963, $p < .0005$, non-gesture items had an intraclass correlation of .992, $p < .0005$ and gesture items had an intraclass correlation of .987, $p < .0005$.

Results

Preliminary Analyses and Analysis Plan

The distributions of all dependent variables were screened for normality and homoscedasticity within groups and no violations were identified. All cases were independent.

The effect of gesture on narrative comprehension was examined through children's performance on both the free recall task and the specific questions. Performance on the specific questions was then broken down into gesture point questions and non-gesture point questions. Narrative comprehension was analysed in regard to the main effect of gesture type, the main effect of gesture redundancy, and the interaction between gesture type and redundancy. These analyses were done via a series of 3 (gesture condition: deictic, iconic, no gesture) by 2 (redundant, non-redundant) between subjects ANOVAs. The overall main effect of gesture type was not of interest: rather, two planned orthogonal contrasts were run, comparing 1) the two gesture conditions combined vs the no gesture control and 2) the iconic vs deictic gesture conditions, ignoring the no gesture condition.

The main effect of language ability and the interactions between language ability, gesture type and gesture redundancy on narrative comprehension were then investigated, by adding the continuous predictor of PPVT standard score and associated two- and three-way interactions to the above analysis. Analyses conducted were general linear models. PPVT scores were mean centred prior to being entered into the analysis.

Main Analyses

Free recall. A two-way between subjects ANOVA was used to examine the effect of gesture type and gesture redundancy on free recall. In regard to the former, orthogonal contrasts revealed significantly better performance on free recall for the two gesture conditions compared to the no gesture control condition, $F(2,123) = 9.054$, $p = .003$, *partial* $\eta^2 = .069$. There was no significant difference between the deictic and iconic gesture conditions, $F(2,123) = 1.971$, $p = .163$, *partial* $\eta^2 = .016$. There was no significant main effect of redundancy condition on free recall, indicating there was no difference between redundant and non-redundant gestures on participants' free recall performance, $F(1,123) = 1.446$, $p = .231$, *partial* $\eta^2 = .012$. There was no significant interaction between gesture condition and gesture redundancy for free recall, $F(1,123) = .517$, $p = .598$, *partial* $\eta^2 = .008$. See Table 1 for group means.

Table 1

Free Recall Mean and Standard Deviation Scores for Each Condition

	Gesture Condition								
	Deictic			Iconic			No Gesture		
	M	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Redundant	4.27	2.27	0-11	3.18	2.65	0-9	2.10	2.72	0-8
Non-redundant	3.19	2.62	0-8	2.86	1.81	0-7	2.00	1.90	0-5

Gesture point questions. A two-way between subjects ANOVA was used to examine the effect of gesture type and gesture redundancy on performance on the gesture point questions. In regard to gesture type, orthogonal contrasts revealed no significant differences between gesture types, $F(2,123) = .026$, $p = .873$, *partial* $\eta^2 < .0005$, or between the gesture types and the control condition, $F(2,123) = 2.349$ $p = .128$, *partial* $\eta^2 = .019$. There was a significant main effect of gesture redundancy on gesture point question performance, $F(1,129) = 7.439$, $p = .007$, *partial* $\eta^2 = .057$. Averaged across gesture conditions, participants who viewed the redundant gestures performed better than those who viewed non-redundant gestures. There was no significant interaction between gesture type and gesture redundancy for gesture point questions, $F(1,123) = .648$, $p = .525$, *partial* $\eta^2 = .010$. See Table 2 for group means.

Table 2

Gesture Point Question Mean and Standard Deviation Scores for Each Condition

	Gesture Condition								
	Deictic			Iconic			No Gesture		
	M	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Redundant	13.45	4.38	3-19	12.86	3.30	6-18	12.57	4.64	5-20
Non-redundant	11.24	3.77	4-17	12.09	3.49	6-19	10.05	3.14	5-17

Non-gesture point questions. A two-way between subjects ANOVA was used to examine the effect of gesture type and gesture redundancy on non-gesture point question performance. Orthogonal contrasts of gesture type revealed no significant difference between the gesture types, $F(2,123) = .349$, $p = .556$, *partial* $\eta^2 = .001$ and no significant difference between the gesture types and the no gesture control group, $F(2,123) = 3.519$, $p = .063$, *partial* $\eta^2 = .028$. No significant main effect of gesture redundancy, $F(1,123) = .002$, $p = .962$, *partial* $\eta^2 = < .0005$, and no significant interaction between gesture type and gesture redundancy was found, $F(2,123) = .014$, $p = .986$, *partial* $\eta^2 = < .0005$. See Table 3 for group means.

Table 3

Non-Gesture Point Question Mean and Standard Deviation Scores for Each Condition

	Gesture Condition								
	Deictic			Iconic			No Gesture		
	M	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Redundant	5.00	2.05	2-9	5.23	1.97	2-9	4.48	1.89	1-9
Non-redundant	5.00	2.14	1-9	5.27	1.72	2-9	4.38	2.04	2-10

Language ability. Three-way general linear models were used to examine the effects of language ability, gesture type and gesture redundancy on narrative comprehension (i.e., on free recall, gesture point questions and non-gesture point questions). Only the effects involved language ability are reported here; main effects and two-way interactions involving gesture type and gesture redundancy are unchanged from the analyses reported above. Group means for language ability can be found in Table 4. For free recall, the analysis revealed a significant main effect of language ability, $F(1,117) = 6.480$, $p = .012$, *partial* $\eta^2 = .052$, such that there was a positive association between language ability and free recall scores. The analysis revealed no significant interaction effect between language ability and gesture type, $F(2,117) = .104$, $p = .901$, *partial* $\eta^2 = .002$ and no significant interaction effect between language ability and gesture redundancy, $F(1,117) = .141$, $p = .708$, *partial* $\eta^2 = .001$. The analysis also revealed no significant three-way interaction effect between language ability, gesture type and gesture redundancy, $F(2,123) = 1.849$, $p = .162$, *partial* $\eta^2 = .031$.

For gesture point questions, the analysis revealed a significant main effect of language ability, $F(1,117) = 37.515$, $p = <.0005$, *partial* $\eta^2 = .243$, again such that children with higher receptive language abilities performed better on the gesture point questions than children with lower receptive language abilities. The analysis also revealed no significant interaction effect between language ability and gesture type, $F(2,123) = .094$, $p = .910$, *partial* $\eta^2 = .002$ and no significant interaction effect between language ability and gesture redundancy, $F(1,117) = .2.176$, $p = .143$, *partial* $\eta^2 = .018$. The analysis also revealed no significant three-way interaction effect between language ability, gesture type and gesture redundancy, $F(1,117) = .623$, $p = .538$, *partial* $\eta^2 = .011$.

Finally, for non-gesture point questions, the analysis revealed a significant positive main effect of language ability, $F(1,117) = 18.467$, $p = <.0005$, *partial* $\eta^2 = .136$. The analysis revealed no significant interaction effect between language ability and gesture type, $F(2,117) = .261$, $p = .771$, *partial* $\eta^2 = .004$ and no significant interaction effect between language ability and gesture redundancy, $F(1,117) = 1.257$, $p = .264$, *partial* $\eta^2 = .011$. The analysis also revealed no significant three-way interaction effect between language ability, gesture type and gesture redundancy, $F(2,117) = .032$, $p = .969$, *partial* $\eta^2 = .001$.

Table 4

Language Ability Mean and Standard Deviation Scores for Each Condition

	Gesture Condition								
	Deictic			Iconic			No Gesture		
	M	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Redundant	105.73	15.84	83-137	106.73	13.08	77-128	106.81	11.303	86-127
Non-redundant	108.95	10.70	93-129	110.77	11.65	93-131	109.67	9.90	87-126

Discussion

The primary objective of the current study was to investigate the role of gesture types and gesture redundancy on preschool children's narrative comprehension. This was achieved through examining children's comprehension after observing gestures presented in accompaniment with a narrated story. Results were analysed with respect to children's free recall of narrative content, and cued recall of narrative content through specific questions. Study hypotheses were partially supported.

Gesture type was found to be significantly positively related to children's free recall of gesture related story content but not significantly related to performance on the specific gesture questions. This was partially consistent with the first hypothesis, such that iconic and deictic gestures produced better free recall comprehension performance than no gesture, with no significant difference on free recall performance between iconic and deictic gestures. However, this effect only held for free recall: gesture type contrasts were not significant for specific gesture questions.

Gesture redundancy produced the opposite effect. Gesture redundancy was significantly related to children's performance on specific gesture questions, such that children in the redundant gesture conditions performed better on cued recall than those in the non-redundant gesture conditions. However, unlike the effect of gesture type, gesture redundancy was not significantly related to children's performance on free recall. Results were partially consistent with the study hypothesis, which predicted that redundant gestures would produce a superior performance overall compared to non-redundant gestures.

Of primary interest to the current study however was the interaction between gesture type and gesture redundancy. This hypothesis was not supported, as no interaction effects were found between gesture type and gesture redundancy on any of the narrative comprehension dependent measures. There was no difference between the effects of redundant and non-redundant gestures for iconic or deictic gestures compared with no gesture, for either free recall or responses to specific questions. As expected however, there were no effects of gesture type or gesture redundancy on non-gesture points, i.e. on aspects of the narrative that were not associated with gestures in any condition.

Finally, although language ability was significantly positively related to the outcome measures, there was no interaction effect found between language ability and gesture type or gesture redundancy. This was not consistent with the fourth hypothesis, which predicted that comprehension might be differentially influenced by language ability, by observing iconic or deictic gestures compared to no gesture and from redundant gestures compared with non-redundant gestures.

The Effect of Gesture Type on Children's Narrative Comprehension

One of the primary objectives of the current study was to provide support for the previously found effect of gesture type. In light of the results found by Macoun and Sweller (2016), it was predicted that iconic and deictic gestures would facilitate narrative comprehension in children beyond no gesture. Results partially supported this hypothesis. With respect to children's free recall performance, gesture type was found to be significantly related to narrative comprehension. Orthogonal contrasts demonstrated that children who viewed iconic and deictic gestures produced significantly better performance on the free recall question than children who viewed no gesture. No difference was found between children who viewed iconic or deictic gestures. These findings are consistent with the study hypothesis and with previous findings (Alibali et al., 1997; Beattie & Shovelton, 1999; Demir et al., 2014; Goldin-Meadow et al., 1999; Macoun & Sweller, 2016). The facilitative effect of iconic and deictic gestures for narrative comprehension is an important finding for teachers and has implications for teaching strategies. This result suggests that teachers should consciously engage gestural prompts to accompany story narration when in the classroom, to support and enhance children's comprehension of the spoken content. Specifically, Demir et al. (2014) used gestures when narrating a story to children and instructing them to construct their own narrative. Kindergarten children in their study reproduced more goal-directed and well-organised narratives after observing gestures in the task instructions compared to children who did not observe gestures.

Contrary to this positive effect, however, gesture type was not found to be significantly related to children's performance on gesture-specific questions. Orthogonal contrasts revealed no difference between children who viewed iconic or deictic gestures and children who did not observe gesture. There was also no observed difference between children in the iconic and deictic conditions on cued recall performance. This is inconsistent with the relevant study hypothesis and with the results found by Macoun and Sweller (2016). There are a few explanations that could account for this result. Firstly, McNeil et al. (2000) posit in their research that deictic gestures are most beneficial when the subject of the gesture is an object, as the pointing movement can indicate an object effectively, while iconic gestures are most beneficial when the subject of the speech contains an action or a verb, as the movement of the iconic gesture can be used to form an action or describe a concept (such as ‘big’ or ‘round’). Therefore, the absence of a significant effect of gesture type on the specific question responses could be due to the fact that some interview questions were based on a solid object in the visual display, e.g. ‘what animal did the family see on the way home?’ and some were based more on an action or consequence, e.g. ‘what did Daisy’s dad do after he carried her to her room?’. Although all questions were used in both conditions, perhaps there was mixed effectiveness within the questions depending on the gesture type. Investigating question type and the relationship with gesture type might be interesting follow-up research to the current study.

It is curious to note the performance difference in free recall compared to cued recall in light of the fact that participants viewed the same gestures in both cases. The beneficial effect of gesture on free recall is consistent with previous literature (Hostetter, 2011; Macoun & Sweller, 2016; Ping & Goldin-Meadow, 2008). However, it is a unique finding, unsupported by previous literature, that free recall performance is not similar to performance on cued recall of specific questions. Due to the nature of the cued recall questions, children in all conditions were provided with a forced choice alternative and, thus, a 50% chance of guessing the correct answer to all of these questions. Additionally, children in all conditions had a visual cue to the question answers, as objects for the deictic condition were present in all video displays. As children in the non-redundant control condition were still able to recall some of the information which was only presented in gesture in the other non-redundant conditions and did not perform at floor level, this indicates they were attending to the visual display in the video. Consequently, the presence of the visual cues in the video combined with the forced choice alternative may have together improved the performance of children in the control condition on the cued recall questions, preventing the detection of any beneficial effect of gesture.

Research by Ouwehand et al. (2015) supports this assertion, through an investigation of the percentage of time a participant fixates visually on the video model compared to slides on the screen in front of the model. Three conditions were compared in this study: gesture and visual gaze from the model to the task objects in the scene, visual gaze only and no cue. The authors found that there was no difference in mean fixation duration between the instruction conditions. This finding suggests that without a visual or gestural cue to the objects in the scene, participants still spent the same amount of time visually fixating on these objects compared with when they were gesturally oriented toward the objects. This similar amount of fixation time on objects in a visual display provides a potential explanation for the lack of difference between the effectiveness of the gesture types and the control conditions in cued recall performance: children were attending to the visual display accompanying the narrative, with or without the narrator performing gestures. Considering this possibility, it is important to investigate the differential effects of the gesture types on narrative comprehension whereby the objects of interest to the narrative were only present in the deictic condition and participants were not presented with forced choice alternatives compatible with these visual cues. This point is discussed in more detail below.

Although the presence of the items in the video similarly holds true for free recall, the fact that for this measure children were not provided with any prompts as to the correct responses, perhaps increased the effects of the gesture manipulation. A potential explanation for this difference between free recall and cued recall could be due to the cues provided in the question itself. It could be possible that multimodal encoding facilitated by gestures aids retrieval, as seen in the significant effect of gesture on children's free recall performance, and that the presence of a cue in response to the gesture-specific question is masking this effect, providing even those children in the control condition with a fifty percent chance of making the correct response. Thus, even with the inclusion of the visual display, it is the nature of the difference between the free recall and cued recall questions resulting in the differences between these variables. A potential way to investigate the nature of this question type difference would be to separate the gesture-specific questions into those that were answered independently and those that required a cue to answer the question. In this way, the specific effects of the free and cued recall response types can be evaluated.

The Effect of Gesture Redundancy and the Differential Effectiveness of Gesture Type and Gesture Redundancy on Children's Narrative Comprehension

Another primary objective of the current study was to ascertain the relative effectiveness of redundant or non-redundant gestures on children's narrative comprehension. As noted above, the main effect of redundancy was not of primary interest to the current study, as results would be heavily pulled by the control condition, in which children in the non-redundant no gesture condition received less information overall than children in the redundant control condition. A main effect of redundancy was detected for cued recall but not free recall, supporting the hypothesised direction. As expected, there was a difference between the redundant and non-redundant group means for the control conditions, supporting the assumption that the main effect of gesture redundancy would be influenced by the control groups.

Of primary interest to the current study however was the interaction between gesture redundancy and gesture conditions. Specifically, it was expected that there would be a larger performance difference between children in the iconic and deictic gesture conditions and the no gesture conditions in the non-redundant group than the redundant group. In other words, it was hypothesised that non-redundant gestures would be more beneficial in aiding children's narrative comprehension than redundant gestures. This predicted effect was based primarily on the conclusion in the meta-analysis conducted by Hostetter (2011), that studies investigating non-redundant gestures produced effect sizes almost twice as large as those investigating redundant gestures. Subsequently, this is the first study to compare the effects of observing redundant and non-redundant iconic vs deictic gestures directly and an affirmative for this hypothesis would provide support for the interactive contribution account of the function of gesture. The results did not support this hypothesis. The current analysis found no interaction effects in performance either on free recall questions or on the specific gesture-point questions.

The absence of an interaction between gesture type and gesture redundancy is inconsistent with past literature. For example, Singer and Goldin-Meadow (2005) found deictic gestures most effective when they did not match the accompanying speech. That is, these authors found pointing to one strategy when teaching mathematics while verbally presenting a different strategy to come to the same result was the most efficacious condition for learning in children. The current study's lack of a significant interaction may be due to the differential results for the main effects of gesture type vs gesture redundancy and their associated effects on the two dependent variables. Namely, there was a main effect of gesture type only evident for free recall items and a main effect of gesture redundancy only found for specific cued recall items.

The non-significant interaction between the effectiveness of redundant and non-redundant gestures is an interesting finding, although the absence of a performance difference between redundant and non-redundant gestures has been found previously (Wakefield & James, 2015). These authors suggested a lack of difference can be explained by the attentional hypothesis of the function of gesture, in that gestures primary function is to provide a cue to visual attention to the narrative rather than adding any further semantic support to comprehending the story content. Future research including beat gestures could provide further clarity on the relevance of the attentional account of gesture function. As beat gestures are not semantically related to speech by nature, their support for learning is based purely on drawing attention to the accompanying speech and could be used to validate the attentional mechanism account of gesture function.

Corresponding to the comments above, the visual presence of the objects in all conditions may have affected the results. For example, Van Gog, Verveer, and Verveer (2014), in a study investigating whether participants looked more at a narrator or at a visual display during a video demonstration, found that participants spent more time visually fixating on the physical display than on the video model/narrator. Specifically, this increased fixation time on the display implies that it could be the presence of the visual display, rather than the semantic content of the speech and the accompanying gesture that is facilitating children’s learning. As this is the first investigation to directly compare redundant and non-redundant gestures, it would be pertinent to conduct further research in order to elucidate the function of gesture redundancy in children’s narrative comprehension. This will be discussed in more detail below.

The Role of Language Ability in the Facilitative Effect of Gesture on Children's Narrative Comprehension

The final hypothesis that children with lower language ability would benefit more from observing gestures than those with higher language ability was not supported by the study results. That is, it was expected that an interaction would exist between language ability and gesture. Although there was the expected main effect of language ability on both free recall and gesture-specific questions, there was no interaction effect found between language ability and gesture type for performance on either free recall or cued recall. Further, there was no interaction effect found between language ability and gesture redundancy, and no three-way interaction was found between language ability, gesture type and gesture redundancy on free recall or cued recall.

These results do not lend support to the cognitive load reduction account of the function of gesture, as the presence of gestures did not facilitate comprehension in children with a lower functioning language system, by reducing the strain on working memory. This is inconsistent with the suggestion made by Wakefield and James (2015). These authors suggested that the presence of gesture accompanying speech would reduce the demand on the listeners working memory system and allow for easier processing of to-be-learned information. Concordantly, Goldin-Meadow et al. (1999) suggested iconic gestures may be easier to comprehend than speech as they possess semantic properties independent of speech and don't need a translation. Therefore, these gestures should enhance comprehension in those with lower language capacity. These results are discussed further below, in light of the potential function of gestures in learning.

A Functional Account for Gesture's Facilitative Effect on Learning

Within the literature, there are competing theoretical explanations for gesture's functional support in the classroom. The current study was not designed to provide conclusive support for one specific mechanism responsible for the facilitative effect of gesture on learning. However, the hypotheses investigated have lent differential support to the competing theoretical accounts of the function of gesture as a non-verbal learning support, through a comparison of different gesture types (deictic and iconic gestures) in light of their semantic relationship with the accompanying verbal content (redundant or non-redundant with the verbal content).

As expected in the main effect of redundancy, redundant gestures were found to be more beneficial for children's narrative comprehension in cued recall than non-redundant gestures. That is, providing the same information to the listener in the verbal content and the accompanying gestures was more effective for children's learning than providing gestural information that was supplementary to the accompanying speech. However, the significant main effect here was influenced by the control group who saw no gestures, which needs to be taken into consideration. Considering tis, the result lends tentative support to the dual coding explanation of mental imagery theorised by Clark and Paivio (1991) and is consistent with previous literature (Flevares & Perry, 2001; Valenzeno et al., 2003). The dual coding theory posits that simultaneous presentation of complementary speech and gestures has an additive effect, creating a rich mental representation of the content being presented to the listener. The facilitative effect of redundant gestures lends credit to the assumption of dual coding theory that a richer mental representation of the to-be-learned information activates more nodes in the neural network and therefore allows for easier comprehension, consolidation and retrieval of the information. Hostetter and Alibali (2008) support this account of the function of gesture, suggesting the advantageous nature of redundant gestures is a consequence of the simultaneous activation of the mental imagery and language systems. Specifically in the classroom, Flevares and Perry (2001) found that teachers are most effective when the different presenting modalities (visual and verbal) are presented coherently.

Concordantly, Goldin-Meadow et al. (1999) support the dual coding explanation, suggesting the addition of supplementary gestural information distracts the listener from the semantic information presented in the speech. However, this result is unable to exclude the interactive contribution theory support by the findings of Macoun and Sweller (2016). These authors found children who viewed non-redundant representational gestures performed better on measures of narrative recall than those who viewed beat or no gestures. As this indicates the facilitative effect of supplementary gestures compared with no gestures, the interactive contribution hypothesis was supported. In the current study, although redundant gestures were significantly more effective than non-redundant gestures, the non-redundant gestures were still effective to some extent in supporting children’s comprehension. This is evident due to the significant effect of iconic and deictic gestures found compared to no gesture for free recall. Thus, although Macoun and Sweller (2016) were able to definitively support the dual coding theory above the interaction contribution theory, the current study results have provided support for both explanations to some extent. This highlights the need for more research investigating the facilitative influence of gesture on classroom learning, particularly regarding the redundancy of the gesture presented.

However, the communicative effect of redundant gestures was only found here for performance on the specific gesture questions. No effect of gesture redundancy was found for performance on free recall. Therefore, the attentional account of the facilitative effect of gesture is also potentially supported by the current study results. As no difference between redundant and non-redundant gestures was found for free recall, the results suggest that it is not the semantic relationship between the gesture and the verbal content that is relevant here, but rather just that the presence of gesture aids comprehension. Gestures provide a visual cue to attend to the narrative, rather than supplying any semantic advantage to learning the verbal content. The attentional account of the facilitative effect of gesture has been both supported (Demir et al., 2014; Theakston et al., 2014) and challenged (Alibali et al., 2001; Macoun & Sweller, 2016; Woodall & Folger, 1985) in previous literature. As the current study's findings lend partial support to the dual coding theory, interactive contribution account and the attentional explanation for the facilitative function of gesture for learning, and are contrary to some previous research, it is pertinent that future research attempts to clarify the relationship between gesture redundancy and comprehension further, particularly the facilitative function of gesture.

Finally, it was hypothesised that if a relationship existed between language ability and gesture type on performance, this would lend support for the cognitive load reduction account of the facilitative effect of gesture, consistent with the suggestion made by Wakefield and James (2015). The current results did not support this hypothesis, suggesting it is not the relief of cognitive load on children resulting in the facilitative effect of gestures on narrative comprehension. This finding was not consistent with previous literature and was unable to provide any clarity as to the role of language ability. Contrary to the current findings, results from Kirk et al. (2011) and Mainela-Arnold et al. (2014) indicate that observing gesture can improve comprehension in children with low language ability, producing performance in these children similar to that of children with high language ability. In contrast, Thompson and Massaro (1994) found the presence of deictic gestures aided comprehension in children with high language ability to a greater extent than those with low language ability. The current study was unable to lend support to either account of the relationship between language ability and gesture. The failure to find an interaction effect here could be due to a lack of variance in language ability in the current sample, as detailed below.

Limitations and Future Directions

A key limitation of the present study was the presence of the visual display in all conditions. Although the visual display was necessary for the deictic condition and maintained in the display for consistency across conditions, its presence may have influenced recall of children in the control group. If the children in the control conditions spent some time attending to the visual display in the video, this would have improved accuracy to the specific questions, and in particular, in the questions where only one of the forced choice alternatives was present in the visual display. Future research should address this limitation by using only iconic gesture and no gesture conditions, to investigate the relationship between gesture type and recall, gesture redundancy and recall and the interaction between gesture type and gesture redundancy. This type of investigation would be justified, as Ping and Goldin-Meadow (2008) found iconic gestures were effective in supplementing speech regardless of whether the speech referent was present in the visual display or not. Therefore, it would be appropriate to assume iconic gestures are effective regardless of the presence of the visual display and could be used to further investigate the effectiveness of gesture type and gesture redundancy.

A further limitation in this study was the insufficient variance in language ability in the sample. As the participants were recruited based on age, not language ability, this resulted in a lack of variability in language ability in the sample. Due to the fact that some previous studies have found an advantageous effect of language ability when observing gesture in children with low language ability, it is possible that a greater difference between those with low and high language ability, or a lower minimum language level in the sample would have produced a significant interaction between language ability and gesture type. Some past research supporting the relationship between language ability and the presence of gestures had a greater age disparity in the samples. In the absence of a definitive language ability measure, it is possible to choose two age groups at two different developmental periods and infer a linguistic difference in ability. Thus, future research could endeavour to investigate two distinct age groups, such as preschool children and year 4 children, potentially resulting in a higher likelihood of finding a significant result of language ability.

Additionally, it was suggested above that a significant interaction between language ability and gesture presence on free recall would have provided support for the cognitive load reduction hypothesis of gesture function. The current study did not actually measure cognitive load / working memory capacity specifically, however. As such, a study attempting to consolidate this theory by analysing a sample with a larger variance in language ability might also benefit from the inclusion of a measure of working memory capacity. Inclusion of such a measure would provide a clearer test of the relief the presence of gestures has on working memory and cognitive resources for the listener.

Practical Implications

The current study has contributed to both the growing body of research evidence investigating the use of gesture as a non-verbal learning support in education, as well as to the practical application of hand gestures to narrative comprehension by teachers and other educators. Despite the limitations noted above, results have supported the use of hand gestures when narrating stories to preschool children to some extent, and opened new avenues for further research to consolidate and improve this domain of research in educational psychology. In addition to providing suggestions for future research, the current findings can be used by teachers to enhance the learning experience for their students.

Effective narrative comprehension at a young age is a vital skill for children’s development, one that has been found to be associated with better reading comprehension and school achievement at a later age (Dickinson & McCabe, 2001; Paris & Paris, 2003). Narratives make real world concepts and abstract concepts (e.g., good and evil, happy and sad) accessible to children through the exploration of these ideas in characters and concrete story lines (Egan, 1993). The current study has added to the growing body of literature regarding the most effective way to teach stories to children, through analysing the value of hand gestures as non-verbal learning support lend to narrative comprehension. It is clear from the current study and past literature that representational gestures are effective in teaching, and the novel findings here regarding the redundancy of gesture add to this. Flevares and Perry (2001) have noted that teachers use gestures in everyday classroom learning. The research here and in the body of literature reviewed is working towards fostering and guiding the natural tendency in teachers to use gestures in order to enhance and improve children’s learning experience. In particular, as the first study to directly compare the use of redundant and non-redundant iconic and deictic gestures, the current research has added to the growing body of literature as well as stimulated further investigation and discussion in this area.

Conclusion

The use of hand gestures as non-verbal learning support is of great interest in developmental psychology. The current study has successfully investigated both gesture types and gesture redundancy in order to elucidate the most efficacious ways in which hand gestures can facilitate the educational experience for children. Despite mixed results, the findings here have supported the role of iconic and deictic gestures in children's narrative comprehension to some extent, and have provided grounds for further investigation into the facilitative function of gesture. Although the current study did not intend to provide conclusive evidence for one specific mechanism of gesture function in education, the results have provided potential support for a number of these mechanisms, namely the dual coding theory (Clark & Paivio, 1991), the interactive contribution model (Kelly et al., 1999) and the attentional account of gesture function (Theakston et al., 2014). Continued investigation into the relationship between gesture type and gesture redundancy could further clarify support for these mechanisms. In particular, the addition of more cognitive processing measures incorporated in the current study design might provide further insight into the influence gesture has on cognitive processing and, therefore on comprehension and learning in children.

Future research should aim to investigate gesture redundancy through investigation of iconic gestures compared with no gesture, thus removing the potential confound of the visual display in the video stimulus. This might increase the likelihood of a significant interaction between gesture type and gesture redundancy and indicate that the redundancy of gesture is most important when the listener has no visual stimulus to rely on. Additionally, it is unclear as to the role of gestures for children with different language abilities and the current investigation was not able to provide any further clarity on this issue. Therefore, it would be pertinent to conduct a study investigating the role of gestures and gesture redundancy on children with a greater variety of language abilities.

The current study has advanced research into the facilitative effects of gestures on children's narrative comprehension. Results here contribute to a wide body of research aiming to incorporate hand gestures into teaching and suggest representational gestures should be utilised as a teaching tool to improve comprehension and augment story time. Overall, the study suggests that what we do with our hands influences young minds.

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Appendices

Appendix A: Director Information Form

Department of Psychology
Faculty of Human Sciences
MACQUARIE UNIVERSITY NSW 2109
Phone: +61 (2) 9850 8084
Fax: +61 (2) 9850 8062

Email: naomi.sweller@mq.edu.au

MACQUARIE University SYDNEY·AUSTRALIA

Director Information Form

Stories and Gesture: Redundant and Non-Redundant Gesture in Narrative Comprehension

Dear Director,

I am writing regarding the possibility that you might allow us to conduct a study involving Preschoolers (ages 3 to 6) at your school. In addition to seeking your own permission, we will also request that of parents.

The purpose of the study is to examine whether different types of gesture, and their relevance to the verbal content of the story, aid a child's understanding of the narrative being presented, and thus, aid children's learning and comprehension of the story. Please note that for the purposes of the study, children are required to be fluent in the English language.

To carry out the study, children will be asked to participate in 3-4 short tasks. The children will be shown a three-minute video of a narrator telling a story using a specific form of gesture, depending on the condition your child is assigned to. Following this, the children will be required to complete a brief join the dots filler task. The interviewer (Emma Zicat) will then ask the children a series of questions about the story they viewed at the beginning of the study, and their responses will be recorded via a video recording device. This will allow the interviewer to pay attention to the children while they are answering the questions. Finally, the children will complete the Peabody Picture Vocabulary Test-4 (PPVT) Form A (Dunn, L.M., & Dunn, D.M., 2007). This will involve asking the children to point at cartoon images in response to words given, such as "ball". In addition, the children will receive stickers for their completion of the tasks. This will all take place in one session taking no longer than 30 minutes to complete.

Similar studies conducted by Dr Naomi Sweller in the past showed that children greatly enjoyed the tasks and that parents were happy to have their child participate. We expect the children will enjoy one-on-one time and a break from the classroom. We do not anticipate that there will be any adverse consequences for children as a result of taking part in our study. Nonetheless, it will be made explicit to children that they are free to return to class at any stage without consequence if they wish to. Although we hope that this research will indicate future teaching tools for parents and teachers we cannot and do not guarantee that children will receive any personal benefits from the study.

Any video, audio and written information that is obtained in connection with this study and that can be identified with the school or the children will remain confidential and will be disclosed only with your permission or as required by law. This information will be securely stored in the office of the Chief

Investigator (Naomi Sweller), will be accessed only by the researchers directly involved with this project, and will be erased 5 years after the end of the study. The results of research will be published in academic journals. In any publication, information will be presented in such a way that the children will not be able to be identified. We will send out a summary of the results to your school upon the completion of the study for dissemination to parents.

Prior to the commencement of the study, an information letter and consent form will be sent to parents. Participation would be entirely voluntary, requiring both child and parental consent. We will provide you with copies of our consent form, and would like to ask you to please disseminate these to parents. We have ethics approval for this study from the Human Research Ethics Committee of Macquarie University. However, if you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Ethics Review Committee through its Secretary (telephone 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Should you wish to contact us with regard to any aspect of this research, you can do so by contacting Dr Naomi Sweller on 9850 8084. We shall follow this letter with a telephone call in a few days' time. In the meantime, thank you for taking the time to consider our request. We look forward to speaking with you soon.

Yours faithfully

Naomi Sweller, PhD	Emma Zicat
Senior Lecturer in Psychology	Masters of Research student
Macquarie University	Macquarie University

This information sheet is for you to keep.

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Appendix B: Parental Information and Consent Form

Department of Psychology
Faculty of Human Sciences
MACQUARIE UNIVERSITY NSW 2109
Phone: +61 (2) 9850 8084
Fax: +61 (2) 9850 8062

Email: naomi.sweller@mq.edu.au

MACQUARIE University SYDNEY·AUSTRALIA

Chief Investigator's / Supervisor's Name & Title: Dr Naomi Sweller

Parent (or Guardian) Information and Consent Form

Name of Project: Stories and Gesture: Redundant and Non-Redundant Gesture in Narrative Comprehension

Dear Parent/Guardian,

You are invited to permit your child to participate in a study concerning the use of gesture in aiding children's understanding of a narrative. The purpose of the study is to examine whether different types of gesture, and their relevance to the verbal content of the story, aid a child's understanding of the narrative being presented, and thus, aid children's learning and comprehension of the story. Your child was selected as a possible participant in this study because he or she falls into the age range (3-5 years old). Please note that for the purposes of the study, children are required to be fluent in the English language.

The study is being conducted by Dr Naomi Sweller (phone: (02) 9850 8084, email: naomi.sweller@mq.edu.au) and Miss Emma Zicat (phone: 0432305621, email: emma.zicat@students.mq.edu.au). This research is being undertaken by Emma Zicat to meet the requirements of the Master of Research under the supervision of Dr Naomi Sweller of the Department of Psychology.

If your child participates, they will be asked to participate in 3-4 short tasks. Your child will be shown a three-minute video of a narrator telling a story using a specific form of gesture, depending on the condition your child is assigned to. Following this, your child will be required to complete a brief join the dots filler task. The interviewer will then ask your child a series of questions about the story they viewed at the beginning of the study, and their responses will be recorded via a video recording device. This will allow the interviewer to pay attention to your child while they are answering the questions. Finally, your child will complete the Peabody Picture Vocabulary Test-4 (PPVT) Form A (Dunn, L.M., & Dunn, D.M., 2007). This will involve asking your child to point at cartoon images in response to words given, such as "ball". In addition, the children will receive stickers for their completion of the tasks. This will all take place in one session taking no longer than 30 minutes to complete.

The session will take place in your child's school, in a location decided with the Director. Any location chosen will not be physically out of sight of centre staff and the general flow of activities. The session will likewise take place at a time decided with the Director and your child's teachers. Your child will not be taken away from important activities such as lunch or sleep time.

Your child's participation in the study is completely voluntary – you are not under any obligation to consent. Your child may withdraw from the study at any time – or you may withdraw your child from the study – at which point all written and audio/video records of your child's participation will be erased. Your child's withdrawal from this study will not in any way affect their academic standing or relationship with the school or with Macquarie University.

Similar studies conducted by Dr Naomi Sweller in the past showed that children greatly enjoy these sorts of tasks. We do not expect that there will be any adverse consequences for your child as a result of taking part in our study. Rather we anticipate that children will enjoy one on one time and a break from the classroom to play and hear a story. Your child will be returned to their class if he or she requests this at any stage or if he or she appears distressed. Although we hope that this research will indicate future teaching tools for parents and teachers we cannot and do not guarantee that children will receive any personal benefits from the study.

Any information or personal details gathered in the course of the study are confidential, except as required by law. No individual will be identified in any publication of the results. The only persons with access to individual data will be the experimenters, Dr Naomi Sweller and Miss Emma Zicat. All information will be stored in a password protected computer or in a locked cabinet. A report of the study may be submitted for publication but individual participants will not be identifiable in such a report. If you are interested in the results of the study, you may contact Emma Zicat or Naomi Sweller directly in October 2017. A summary will also be sent to your child's school for dissemination.

Any video, audio and written information that is obtained in connection with this study and that can be identified with you or your child will remain confidential and will be disclosed only with your permission or as required by law. This information will be securely stored in the office of the Chief Investigator (Dr Naomi Sweller), will be accessed only by the researchers directly involved with this project, and will be erased 5 years after the end of the study.

When you have read the information please contact Emma Zicat if you wish to discuss the research further or have any questions about the study. Please discuss this project with your child and sign the attached form only after your child has indicated that he or she would like to participate.

If you decide to allow your child to participate in this study we would be grateful if you returned the attached consent form to your child's class teacher or the school office within the ***next 2 days or as soon as possible.***

I, (*participant's name)* have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:____

(Block letters)

Participant's Signature: ____________________________ Date:______________________

Investigator's Name:____

(Block letters)

Investigator's Signature:_________________________ ___ Date:______________________

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics & Integrity (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Department of Psychology
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MACQUARIE University SYDNEY·AUSTRALIA

Email: naomi.sweller@mq.edu.au

Gesture and Theory of Mind

I (*print name*)……………………………give consent to the participation of my child (*print name*) ……………………………………in the research project described below.

TITLE OF PROJECT: Gesture and Theory of Mind

CHIEF INVESTIGATOR: Dr Naomi Sweller (Details above)
RESEARCHER: Emma Zicat

0432305621

emma.zicat@students.mq.edu.au

In giving my consent I acknowledge that:

1. The procedures required for the project and the time involved have been explained to me and any questions I have about the project have been answered to my satisfaction

2. I have read the Parent Information Sheet and have been given the opportunity to discuss the information and my child's involvement in the project with the researchers

3. I have discussed participation in the project with my child and my child assents to their participation in the project

4. I understand that that my child's participation in this project is voluntary; a decision not to participate will in no way affect their academic standing or relationship with the school and they are free to withdraw their participation at any time.

5. I understand that my child's involvement is strictly confidential and that no information about my child will be used in any way that reveals my child's identity.

6. I understand that video and audio recordings will be made as part of the study. These recordings will take place during March to October 2016 during school hours.

Parent/ Guardian's Name…………………………………………………………………………………….

Child's Name…………………………………………………………………………………….

Child's date of birth...

Signed…………………………………………………………………………………..

Date……………………………… …………………………………………………….

Appendix C: Narrative Script with Gesture Points

<u>REDUNDANT NARRATIVE</u>

An Afternoon at the Park

There was once a girl called Daisy. One afternoon Daisy went to the park with her mum, her dad and her little brother Joey. First, Daisy played on the swings (**Deictic: Point to swing set, Iconic: Mime swinging back and forth with hands**), going back and forth, back and forth. Second, she went super fast down the slide (**Deictic: Point to the slide, Iconic: Tilt arm on a diagonal, other hand traces down**). Woosh! Suddenly, Daisy's mum realized it was really quite sunny so she called Daisy over to her to give her a hat **(Deictic: Point to hat, Iconic: Mime putting on a hat with two hand – one at front of head and other at back**), and then Daisy went off to play again. Later, her mum found a ball in her bag for Daisy and her brother to play with together. Daisy's brother threw the ball (**Deictic: Point to a ball, Iconic: Shape circular ball with hands**) to Daisy and she caught it with two hands. Her mother and father were so happy with their two children for playing with the ball so well they clapped their hands! The two children then played on Daisy's favourite piece of equipment. They went up and down, up and down on the see-saw (**Deictic: Point to see saw, Iconic: Tilt arm on diagonal and move up and down**). Daisy could spend hours playing on this – she loves it that much! But after all of these activities at the park the two children were feeling hungry and sleepy, so Daisy and her family drove home in the car (**Deictic: Point to car, Iconic: Make steering wheel with hands – move left to right**). On the way home they were lucky enough to see a colourful bird (**Deictic: Point to bird, Iconic: Thumbs joined – make flapping motion with hands**)! Daisy asked her mum if she could have one as a pet and her mum said "maybe for your birthday". This excited Daisy. Back at home; Daisy's mum cooked (**Deictic: Point to stove in kitchen, Iconic: Arm curled as if holding a pot and other hand makes stirring motion**) some delicious dinner in her brand new kitchen (pause) while the children were busy reading a book (**Deictic: Point to book,**

Iconic: Mime reading book, palms open folding inwards and out). Then the family sat down to eat a beautiful meal together. Spaghetti, yum! After dinner Daisy's dad carried her into her bedroom and tucked her into bed (**Deictic: Point to bed, Iconic: Mime sleeping with head on hands**), where she fell fast asleep. What a big afternoon!

NON-REDUNDANT NARRATIVE

An Afternoon at the Park

There was once a girl called Daisy. One afternoon Daisy went to the park with her mum, her dad and her little brother Joey. Daisy ran to play on the playground, (**Deictic: Point to swing set, Iconic: Mime swinging back and forth with hands**), going back and forth, back and forth. Then she wanted to go super fast (**Deictic: Point to the slide, Iconic: Tilt arm on a diagonal, other hand traces down**). Woosh! Suddenly, Daisy's mum realized it was really quite sunny so she called Daisy over to her to give her something to protect her from the sun (**Deictic: Point to hat, Iconic: Mime putting on a hat with two hand – one at front of head and other at back**), and then Daisy went off to play again. Later, her mum found a ball in her bag for Daisy and her brother to play with together. Daisy's brother threw something (**Deictic: Point to a ball, Iconic: Shape circular ball with hands**) to Daisy and she caught it with two hands. Her mother and father were so happy with their two children for playing with the ball so well they clapped their hands! The two children then played on Daisy's favourite piece of equipment. They went up and down, up and down (**Deictic: Point to see saw, Iconic: Tilt arm on diagonal and move up and down**). Daisy could spend hours playing on this – she loves it that much! But after all of these activities at the park the two children were feeling hungry and sleepy, so Daisy and her family went home (**Deictic: Point to car, Iconic: Make steering wheel with hands – move left to right**). On the way home they were lucky enough to see a colourful animal (**Deictic: Point to**

bird, Iconic: Thumbs joined – make flapping motion with hands)! Daisy asked her mum if she could have one as a pet and her mum said “maybe for your birthday”. This excited Daisy. Back at home, it was dinnertime so Daisy’s mum went to the kitchen (**Deictic: Point to stove in kitchen, Iconic: Arm curled as if holding a pot and other handmakes stirring motion**) while the children were busy (**Deictic: Point to book, Iconic: Mime reading book, palms open folding inwards and out**). Then the family sat down to eat a beautiful meal together. Spaghetti, yum! After dinner Daisy’s dad carried her into her bedroom and tucked her in (**Deictic: Point to bed, Iconic: Mime sleeping with head on hands**), where she fell fast asleep. What a big afternoon!

Appendix D: Join-the-Dots Filler Task

Appendix E: Interview Protocol, Version A

Interview Protocol A:

Now I am going to ask you some questions about the story you saw told on the computer. If you don't know the answer you can just guess, okay?
Free recall question: First, please tell me everything you remember about the story you saw on the computer.

Now I am going to ask you some more questions.

1. What was the name of the girl's brother?
If unable to answer:

a Nicholas
b Joey

2. Why were Daisy's mother and father so happy with Daisy and her brother at the park?
If unable to answer:

a Because they played with the ball together so well
b Because they did not run away

3. Why did Daisy and her family leave the park
If unable to answer:

a Because they wanted to get home before it got dark
b Because the children were feeling hungry and sleepy

4. What did the family have for dinner?
If unable to answer:

a Spaghetti
b Vegetables

5. Who tucked Daisy into bed?
If unable to answer:

a Her Mum
b Her Dad

6. What piece of equipment did Daisy go on at the park that went back and forth?
If unable to answer:

a Swings
b Flying fox

7. What piece of equipment did Daisy go down super fast on?
If unable to answer:

a Fireman's Pole
b Slide

8. What did Daisy's brother throw to Daisy?
If unable to answer:

a Ball
b Stick

9. What did Daisy's mum do when the family arrived home?
If unable to answer:

a Go upstairs
b Cook dinner

10. After Daisy's dad carried her to her room what did he do?
If unable to answer:

a Tuck her into bed
b Play with her and her soft toys

11. What was Daisy's favourite piece of equipment?
If unable to answer:

a Ladder
b See saw

12. What did Daisy's mum do to protect Daisy from the sun at the park?
If unable to answer:
Did she. . .

a Give her a hat
b Get Daisy to play under the shade of the tree

13. How did the family get home?
If unable to answer:

a By walking
b By car

14. What type of animal did the family see on the way home?
If unable to answer:

a A bird
b A dog

15. While Daisy's mum was cooking dinner what were the children busy doing?
If unable to answer:

a Having a bath
b Reading a book

Appendix F: Interview Protocol, Version B

Interview Protocol B:

Now I am going to ask you some questions about the story you saw told on the computer. If you don't know the answer you can just guess, okay?
Free recall question: First, please tell me everything you remember about the story you saw on the computer.

Now I am going to ask you some more questions.

1. What was the name of the girl's brother?
If unable to answer:

a Joey
b Nicholas

2. Why were Daisy's mother and father so happy with Daisy and her brother at the park?
If unable to answer:

a Because they did not run away
b Because they played with the ball together so well

3. Why did Daisy and her family leave the park
If unable to answer:

a Because the children were feeling hungry and sleepy
b Because they wanted to get home before it got dark

4. What did the family have for dinner?
If unable to answer:

a Vegetables
b Spaghetti

5. Who tucked Daisy into bed?
If unable to answer:

a Her Dad
b Her Mum

6. What piece of equipment did Daisy go on at the park that went back and forth?
If unable to answer:

a Flying fox
b Swings

7. What piece of equipment did Daisy go down super fast on?
If unable to answer:

a Slide
b Fireman’s Pole

8. What did Daisy’s brother throw to Daisy?
If unable to answer:

a Stick
b Ball

9. What did Daisy’s mum do when the family arrived home?
If unable to answer:

a Cook dinner
b Go upstairs

10. After Daisy’s dad carried her to her room what did he do?
If unable to answer:

a Play with her and her soft toys
b Tuck her into bed

11. What was Daisy’s favourite piece of equipment?
If unable to answer:

a See saw
b Ladder

12. What did Daisy’s mum do to protect Daisy from the sun at the park?
If unable to answer:
Did she. . .

a Get Daisy to play under the shade of the tree
b Give her a hat

13. How did the family get home?
If unable to answer:

a By car
b By walking

14. What type of animal did the family see on the way home?
If unable to answer:

a A dog
b A bird

15. While Daisy’s mum was cooking dinner what were the children busy doing?
If unable to answer:

a Reading a book
b Having a bath

Appendix G: Ethics Approval

Dear Dr Sweller,

Re: "Stories and Gesture: Redundant and Non-Redundant Gesture in Narrative Comprehension"(5201700076)

Thank you very much for your response. Your response has addressed the issues raised by the Faculty of Human Sciences Human Research Ethics Sub-Committee and approval has been granted, effective 20th February 2017. This email constitutes ethical approval only.

This approval is subject to the following condition:

1. Please forward all correspondence and approval from preschools and childcare centres when they become available.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research

The following personnel are authorised to conduct this research:

Dr Naomi Sweller

Ms Emma Zicat

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 20th February 2018

Progress Report 2 Due: 20th February 2019

Progress Report 3 Due: 20th February 2020

Progress Report 4 Due: 20th February 2021

Final Report Due: 20th February 2022

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/resources

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Sub-Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Sub-Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/managing_approved_research_projects

5. Please notify the Sub-Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/managing_approved_research_projects

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide theMacquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of approval to an external organisation as evidence that you have approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this email as this is your official notification of ethics approval.

Yours sincerely,

Dr Shirley Wyver, A/Prof Paul Sowman and Dr Peter Roger
Deputy Chairs
Faculty of Human Sciences
Human Research Ethics Sub-Committee

FHS Ethics

Faculty of Human Sciences Ethics

C5C-17 Wallys Walk L3

Macquarie University, NSW 2109, Australia

T: +61 2 9850 4197 | http://www.research.mq.edu.au/

Ethics Forms and Templates

http://www.research.mq.edu.au/current_research_staff/human_research_ethics/resources

The Faculty of Human Sciences acknowledges the traditional custodians of the Macquarie University Land,

the Wattamattageal clan of the Darug nation, whose cultures and customs have nurtured and continue to

nurture this land since the Dreamtime. We pay our respects to Elders past, present and future.

MACQUARIE University