Semantic priming is faster processing of a word following presentation of a word related in meaning (Lucas, 2000). An example of this would be if a person were reading about a YACHT race, the word BOAT is easier to process due to the related meanings having already been activated in semantic memory. Semantic priming is believed to be caused by two processes, an automatic process and a controlled process.

The automatic model proposes that related words are linked in the brain due to similarities (Collins & Loftus, 1975) and are activated without conscious control due to automatic spreading activation (ASA) within related cognitive networks. These networks were expanded on by Stolz and Besner (1996) as moving upwards from a word level through to the semantic level. Semantic priming, therefore, is when activation from the semantic storage level speeds the recognition of a second concept at the word level. The overlap of the second word’s semantic relatedness makes word recognition easier because it, in essence, has already been processed.

The controlled-process model proposes that people actively use cognitive strategies to connect related words together. One model of this is expectancy generation, in which people consciously attempt to predict the words and ideas that will appear next, especially in sentences (Hutchinson, 2003). Another model for controlled processing is post lexical matching, in which people delay processing of a secondary word until it can be compared to the previous word for evaluation. Processing for the second word is facilitated by a related prime word, whereas it is delayed in the case of an unrelated word (Neely, 1991).

To differentiate between controlled, automatic, and combined processes, researchers have developed methods to limit the capabilities of the controlled processes. Traditional priming studies involve pairs of a first “prime” word to facilitate the processing of a second word, or “target”. These experiments are usually lexical decision tasks, requiring participants to identify presented symbols as words or nonwords. These words are presented in a manner in which an initial word is presented, also known as the prime. This word is followed by a string of letters that could potentially be a semantically associated word, an associatively related word, or a nonword. This design is structured to elicit N400 waveforms for the different categories of words and associations. This encouraged the formation of expectancies due to the pairing format. That is to say, when these words were presently recognizably as pairs, participants naturally assumed they should be related, and could potentially use cognitive strategies to process the words.

To control for the expectancy effect, the single lexical decision task was introduced. Single lexical decision tasks involve participants judging single sets of symbols as words or nonwords, eliminating the expectancy forming process (Hutchinson, 2003). Researchers still faced the problem of post lexical matching, which was addressed by masking the prime words, so they were unnamable. When primes are shown, they are overlaid with nonsense symbols, much like TV fuzz, to hide or mask the perception of that prime. This procedure allows semantic priming, but thwarts use of control mechanisms, since the word is perceptually unnamable..

Event related potentials (ERP) are able to distinguish if semantic priming is exclusively an automatic or controlled process. ERPs measure brain activation as processes occur, with relatively good temporal resolution. The N400 is a negative waveform occurring 400 ms after the participant is presented with a stimulus (Brown & Hagoort, 1993). The N400 has been described as a “contextual integration process”, in which meanings of words are integrated together (Juan Silva-Pereya et al. 2003). When presented with related words, there is an attenuation of the N400; meaning a more positive spike. This difference in waveforms indicates a lack of contextual integration due to word meanings already being activated by the prime word.

Brown and Hagoort (1993) set up a lexical decision task paired with masked priming. No differences were found in the N400 wave between related and unrelated words in the masked prime condition. Brown and Hagoort concluded that this indicated the N400 was a controlled process, because attenuation only occurred when words were known; this supposedly ruled out automatic processes, because the masked prime condition only allowed automatic processes to take place. Masked priming did not allow the participants to consciously name the prime words they had seen, so they were not able to purposefully employ conscious cognitive strategies in processing these words.

Deacon, Heweitt, Yang, and Nagata (2000) found fault with the setup of Brown and Hagoort’s (1993) study. They postulated that Brown and Hagoort’s study had too long of a stimulus onset time, thus eliminating the early, quick automatic processes. Their study replicated that of Brown and Hagoort, but with shorter stimulus onset asynchronies (SOAs). SOAs are the time interval between the prime word presentation and the target word appearance. Short SOAs are thought to only allow for automatic processing because the controlled, attention based processing has not had time to occur. Their study showed the masked primes long enough to enhance priming, while remaining imperceptible. Due to their modifications to the study, Deacon et al found equal attenuation for the masked and unmasked primes. This would indicate that ASA was taking place, as the masked prime condition did not allow controlled processes to take place.

Kiefer (2002) set about to determine if partial information was obtainable from a masked prime for use in making controlled process decisions about target words. In his experiment, judgments requiring information pulled from masked primes were accurate only around the same level as chance guessing, eliminating the chance for controlled processes in the masked event. This result indicates that N400 modulation is probably an automatic processing in the form of ASA.

Letter search is another method used to eliminate semantic priming effects in lexical decision tasks (LDTs). A letter search task is a process in which participants must identify whether or not a letter was present in the prime word or not. This task eliminates semantic priming in LDT’s, but not in repeated word priming (Friedrich et al. 1991). Stolz and Besner (1999) stipulate that this finding indicates the prime word is processed at a lexical, but not semantic level, consequently making semantic activation (SA) not automatic. In opposition to this, Mari-Beffa et al. (2005) found ERP evidence for semantic processing of the prime word during letter search tasks with the attenuation of the N400.

The next step in research focused on relatedness of words and how it affects N400 attenuation. Rolke, Heil, Streb, and Hennighausen (2001) used an attention blink rapid serial visual presentation (RSVP) paradigm, which presented words in rapid succession, causing certain words to be missed, or “blinked“. The words used in this study were identified as having a strong or weak relation, or being unrelated. Strongly related words were identified as being related by the participants, and had the strongest N400 attenuation; weakly related words were sporadically identified as being related by the participants, but showed a slight attenuation of the N400 waveform; and unrelated words were not identified as related, and showed no attenuation. This research illustrates a linear relationship between prime-target strength and N400 modulation.

A linear relationship between prime-target strength and N400 modulation was also found by Kreher, Holcomb, and Kuperberg (2006). Their experiment showed strong N400 attenuation for directly related words, moderate attenuation for indirectly related words, and no attenuation for non-related words. Their study found specifically that with indirectly related words, or words mediated by a third-party word, such as LION and STRIPES (TIGER) were not identified as related by participants, but showed a moderate N400 attenuation. This finding further supports ASA of semantic information.

As previous studies have aimed at discerning the level of relatedness between the prime and target words, the next step in this line of research would be to investigate the effect, if any, of the type of relation shared between the prime and target words. Words can be related semantically or associatively. Associative word pairs are words that are linked in one’s memory by contextual relationships, such as BASKET and PICNIC. Associative words are linked due to the language a person uses and the culture they are a part of. Using words together contextually forges associative relationships in the brain, such as the words ALIEN and PREDATOR, which would be associatively linked for most Americans due to the movies and popular culture. Semantic word pairs are those linked by their shared features, such as WASP and BEE. (Nelson, McEvoy &, Schreiber, 2004)

Associative and semantic relationships between words are something we can measure using existing methods and databases. Maki, McKinley, and Thompson (2004) took the online dictionary, WordNet, and using methods by Jiang and Conrath (1997) and software by Patwardhan and Pederson (2003) created databases of words displaying associative strength and semantic distance between individual words. This database displayed the separable differences between semantic and associated relatedness, as well as forming a common database of semantic distances (levels of semantic relatedness). These distances were measured using the terms Forward Strength (FSG) and the Jiang and Conrath measure of semantic distance (JCN). FSG refers to the probability that a prime word will elicit the target word, representing their level of association. JCN measures the word pairs' informational distance from one another, or their semantic similarities. Therefore, a high FSG score shows strong associative relation, whereas a low JCN score demonstrates a close semantic relationship.

Another useful database, created by Nelson, McEvoy, and Schreiber (2004), is centered on the associative relationships between words. These relationships were measured using extensive norming via a large population of people from many different backgrounds providing feedback on words associated with other words in their memory. Participants were given cue words and asked to write the first meaningfully related or associated word that came to mind. These responses were asked of and averaged over many participants. This method allows for the greatest diversity in participants’ previous life experiences, which prevents the database from being culturally or regionally biased towards one group or another.

The current study seeks to discover if there are significant differences between N400 activation in the brain when presented with semantic-only, associative-only, and unrelated word pairs. Further knowledge of the role different types of word associations play in the N400 waveform will facilitate future research in priming and ERP data. If differences are found in specific types of word relations, the study of cognitive language comprehension will shift towards understanding further these specific differences.

These factors will be studied by presenting participants with a lexical decision task involving a mixed progression of semantically, associatively, and unrelated words. The N400 modulation will be observed in each of these, and any differences noted. It is expected that the N400 modulation will vary from the different types of word relation, as they are organized differently in the brain’s cognitive schemas.