The influence of emotional valence on word recognition in people with aphasia

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Abstract

Although several studies have demonstrated that emotional valence facilitates lexical processing in neurotypical adults, there has been limited work involving people with aphasia. This study explored the effects of valence (valenced/neutral) and polarity (positive/negative) on single word processing. Twenty people with chronic aphasia and 20 neurotypical controls completed a written lexical decision task in which valence was manipulated. An effect of valence (i.e. better performance for valenced vs neutral words) was found in both accuracy and response time in the aphasic group and in response time for controls. Both groups showed an effect of polarity, with aphasic participants generating fewer errors for positive (vs negative and neutral) stimuli, and controls responding more quickly to positive (vs neutral) stimuli. Additionally, performance with positive words was impacted less by aphasia severity than negative and neutral words. The results highlight the importance of valence as a psycholinguistic factor in aphasia assessment and intervention.

Keywords: aphasia, valence, lexical decision, psycholinguistic variables, emotion

1. Introduction

It is widely recognised and has been firmly established in the research literature that emotion and cognition are closely related, with cognitive processes such as attention, memory and learning influenced by emotion (e.g. Phelps, 2004; Um, Plass, Hayward & Homer, 2012; Vuilleumier, 2005). The current study seeks to explore that relationship in people with aphasia; specifically whether the emotional valence of words influences word recognition in this group. Two key terms are used throughout this paper:

1) Emotional valence: the extent to which the emotion evoked by a word is positive or

   negative. The distinction is between valenced words (whether positive or negative) and

   neutral words (e.g. *echo*).

2) Polarity: here the distinction is between positive (e.g. *success*) and negative (e.g. *accident*)

   words.

Several studies have reported that emotional valence facilitates lexical processing: in

neurotypical adults, responses are faster and more accurate to valenced than neutral words in

emotional stroop tests (Algom, Chajut & Lev, 2004), naming (Estes & Adelman, 2008) and

lexical decision tasks (Kousta, Vinson & Vigliocco, 2009). Where studies have explored the

relative effects of positive versus negative words (i.e. polarity effect), the results have been

mixed. Some studies have demonstrated an advantage for negative words (e.g. Kuperman,

Estes, Brysbaert & Warriner, 2014), some for positive words (e.g. Dahl, 2001) and still others

have found no difference between polarities (e.g. Kousta et al., 2009; Yap & Seow, 2014).

The model of motivated attention and affective states (Lang, Bradley, & Cuthbert, 1990) has

been used to account for the latter findings. In the model, emotion arises from activation of

two non-discrete motivational systems that are appetitive or defensive i.e. the human

approaches or avoids the stimuli. These systems have evolved to respond to different

unconditioned stimuli such as emotional valence (for review see Bradley & Lang, 2000).

Emotionally valenced stimuli are therefore motivational in order to protect (negative stimuli)

or to promote survival (positive stimuli). This corresponds with Positron emission

tomography (PET) and functional Magnetic Resonance Imaging (fMRI) studies, which show

activation of the amygdala (which plays a key role in the processing of emotions) for both

positive and negative stimuli (Hamann, Ely, Hoffman, & Kilts, 2002). In studies where

negative valence has been found to have an inhibitory effect on responses, this has been

attributed to the notion of automatic vigilance: there is a delay in disengaging attention from

negative stimuli which results in disrupted processing and slower responses in lexical decision tasks (Estes & Adelman, 2008; Kuperman et al., 2014).

The impact of emotion on linguistic processing has also been investigated in adults with aphasia. However, in comparison with the neurotypical adult research, aphasia research has tended to focus on the influence on lexical processing of a more limited set of words that directly label emotions, e.g. 'anger' (e.g. Cicero et al., 1999). These studies have found a positive impact of these words on performance for sentence identification. Research which has explored emotional valence specifically has consistently found a general facilitative effect of valence: improved accuracy for individuals with aphasia, matching that found in neurotypical adults, though to our knowledge none has specifically explored whether polarity impacts performance in aphasic individuals. Improvements in accuracy have been found in behavioural studies involving written lexical decision (Graves et al., 1981; Landis, 2006), auditory word-to-picture matching (Reuterskiöld, 1991), reading aloud and writing to dictation (Landis et al., 1982), as well as word recall (Berrin-Wasserman, Winnick, & Borod, 2003).

The few studies which have included a control group show that those with aphasia perform similarly to non-aphasic individuals with respect to valence. For example, in Berrin-Wasserman et al's (2003) study 20 individuals with left hemisphere damage, 20 participants with right hemisphere damage and 20 controls generated words or sentences in response to a single written word. They were later asked to recall orally as many of the 24 emotionally valenced and 24 neutral written words as possible. The authors found that emotionally valenced words benefited verbal memory in the patient groups to the same extent as the control group. More recently, Ofek, Purdy, Webster, Gaharahdaghi and McCann (2013) used auditory evoked potentials to explore the processing of personal-emotional and neutral words in 14 adults with aphasia and a control group. They found what the authors describe as a

'more preserved response' to emotional stimuli, that is, P3 amplitudes were larger for emotional stimuli than neutral stimuli in the aphasic group as well as the neurotypical adults. Findings demonstrating a facilitative effect of emotional valence in individuals with left hemisphere damage are unsurprising, since the processing of emotional language is known to involve brain areas undamaged in this population. The amygdala (Landis, 2006) and the right hemisphere are both thought to have an important role in the processing of emotion in spoken language (for review see Borod, Bloom, Brickman, Nakhutina & Curko, 2002).

In addition to the accounts mentioned above which focus on the automatic, motivational processing of emotionally-valenced words, Yap and Seow (2013) used distributional analyses to examine the effects of emotional valence on performance in lexical decision tasks. They provided evidence that valence affects the later stages of word recognition as well as early, preconscious processes in nonaphasic adults and suggested that words with emotional valence have richer semantic representations. That is, words with emotional valence are associated with relatively more semantic information than neutral words. As semantically rich words are recognised faster by neurologically healthy adults (Pexman, Hargreaves, Siakaluk, Bodner, & Pope, 2008), emotional valence may be thought to influence lexical processing in a similar way to other psycholinguistic factors such as frequency and imageability. It has been demonstrated that individuals with aphasia process semantically richer stimuli more effectively (e.g. Conroy, Snell, Sage & Lambon Ralph, 2012; Howard, Best, Bruce & Gatehouse, 1995; Howard & Gatehouse, 2006). Therefore, it is highly possible that emotional valence has a similar facilitative effect for this group as frequency (Laiacona, Luzzatti, Zonca, Guarnaschelli, & Capitani, 2001), imageability, word length and age of acquisition (Nickels & Howard, 1995) as well as the semantic richness of a word (Breedin et al, 1998). If this were the case then there would be important implications

for assessment and intervention in aphasia, particularly in word retrieval deficits, in selecting items which have the best chance of being produced.

Research findings exploring emotional valence with aphasic individuals are difficult to interpret with confidence because it is not evident that the studies have fully controlled for the large number of lexical factors which are known to impact lexical processing including those mentioned above. These include levels of arousal (intensity), even though it is known that arousal is another important predictor of word recognition (Estes & Adelman, 2008). The aim of the current study, therefore, is to explore the effects of emotional valence on lexical processing in a written lexical decision task using positively, negatively and neutrally valenced stimuli matched for many of the key psycholinguistic variables reported in the literature, including levels of arousal. As with previous studies (involving adults with and without aphasia) we predict a facilitative effect of emotional valence.

Our stimuli (from Kousta et al., 2009) also allow us to determine whether polarity (i.e. positive vs negative valence) has an impact on performance in the task. The possible effect of polarity on lexical processing in aphasia has been largely overlooked in previous research. Berrin-Wasserman and colleagues (2003) considered the polarity of their emotional stimuli, and they comment that analyses including comparisons between positive and negative stimuli "failed to show significance" (p.432). As mentioned above, there is some inconsistency in previous research involving neurotypical adults about the effects of polarity. These differences may be due to the fact that studies have utilised different methodologies and different sets of control factors in their datasets. In line with Kousta and colleagues, in the current study we predict no difference between positive and negative stimuli on performance in our written lexical decision task. As our participants include adults with aphasia, the mean age is markedly higher than that of the group of undergraduate students tested in the Kousta study. However, a recent naming study conducted by Blackett and colleagues (2017) found

that although there was no difference between positive and negative stimuli, the effect of emotional valence overall was greater for older adults (aged 60 to 80 years) than younger adults (aged 18 to 27 years), lending support to our predictions about the presence of a valence effect and the absence of polarity effect.

In this study, therefore, we aim to answer the following questions:

- Does emotional valence modulate written lexical decision for people with aphasia and age-matched neurotypical adults, as measured by accuracy and response time? We predict greater accuracy and faster response times for valenced words than neutral words in both participant groups.

- Does polarity of stimulus have a differential influence on accuracy and response time? We predict no difference between polarities in either measure.

We will also examine whether any effects of valence on lexical decision performance exist after controlling for differences in severity in the participants with aphasia. This may reveal whether participants with more severe aphasia benefit more from valenced stimuli. It has been argued (Howard et al., 1995) that words with richer semantic representations are more resistant to damage. Thus, the participants with more extensive brain damage are more likely to have disrupted semantic representations and may only retain those words which have more semantic features. We predict therefore that participants with greater damage (and therefore more severe aphasia) will show relatively better performance with valenced (vs neutral) stimuli than individuals with less severe difficulties.

2. Materials and methods

Testing procedures were approved by UCL Departmental Research Ethics Committee, and all participants gave written informed consent.

2.1. Participants

Forty people participated in this study, 20 people with chronic aphasia (mean age: 61.35, SD: 11.95, range: 36-83; mean years of education: 13.6 years, SD: 2.50) and 20 age, education and gender matched neurotypical controls (mean age: 64.6, SD: 10.28, range: 34-79; mean years of education: 13.75 years, SD: 2.55). An independent samples t-test reported no significant differences between the ages of the groups ($t(38)=.90$, $p=.37$). Both groups comprised 10 men and 10 women, and did not differ significantly for years of full-time education ($t(38)=.66$, $p=.52$).

The participants with aphasia were recruited from a community clinic in London and were at least six months post-stroke. This group had differing communication difficulties, with varying levels of severity as assessed by the Western Aphasia Battery (WAB-R; Kertesz, 2006). The majority of participants presented with anomic aphasia (15/20) and aphasia quotient scores indicated severity ranging from 46 to 96.8 (see table 1 for full details on participants with aphasia). By clinical criteria, three of the aphasic participants would be considered recovered as their aphasia quotient is greater than 93.8. Although problems were not evident for these three individuals at the single-word and sentence level, their difficulties were clearly evident when producing narrative and when abstract or less frequent words were required. Candidates were included if they scored above 50% accuracy on a written word to picture matching task (Subtest 48) and a lexical decision task (Subtest 25) from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 2009). This showed that they could recognise and understand written words, skills needed to access the experimental task.

All participants with aphasia were premorbidly right-handed and eight of them used their non-preferred hand in the experiment (see table 1). Rather than ask all participants in both groups to use their non-preferred hand we judged that differences in task difficulty

across groups were best minimised by allowing all participants to register their responses using their usual hand. All eight participants using their non-preferred hand had been doing so for several months (several years in some cases), and were much more proficient in this than other participants (with and without aphasia) would have been using their non-preferred hand for the first time.

No participants had visual difficulties that could not be corrected with glasses worn during the study. All participants considered English to be their primary spoken and written language. Additional languages were only recorded if the participant reported being fluent.

Insert table 1 about here

2.2. Materials and design

Stimuli were those used by Kousta at al. (2009). There were 228 items in total. These included 114 words: 38 negative (e.g. *enemy*), 38 positive (e.g. *reward*) and 38 neutral (e.g. *boot*) words. Though items varied in ratings of valence on a 9-point scale (negative (M=2.50); positive (M=7.48); neutral (M=5.04)), they were matched in terms of arousal, concreteness, imageability, age of acquisition, familiarity, frequency, orthographic neighbourhood, number of letters, syllables and morpheme, and mean positional bigram frequency. One hundred and fourteen additional words (38 additional negative, positive and neutral words) were also selected, which were matched by length to pair with words in the original list. One letter was then changed to create non-words that were pronounceable and orthographically licit. For full details about the stimuli and a full list of items see Kousta et al. (2009).

2.3. Procedure

Participants were tested individually in a quiet room, and the lexical decision task was delivered by a customized computer program written in Visual Basic .NET, with participants registering a response using the mouse. Participants were instructed that they would see some letters appear on the screen, and that they would to say whether they thought it was a real word (by clicking a green tick on the screen) or a made up word (by clicking a red cross). As with the Kousta study, participants were asked to respond as quickly and accurately as they could. Six practice trials (using items not included in the main task) were completed for all participants to ensure that they understood the task. No participants required repetition of this material. At the start of each trial, a fixation cross appeared in the centre of the screen for 800ms, followed by a letter string (either a word or a non-word) with the tick and cross symbols which remained on screen until participants made their response. The tick and cross symbols were located diagonally below the visual stimulus, and the centre point of each was 80mm from the centre point of the visual stimulus. No time limit was set for registering a response as it was anticipated that the group with aphasia would require longer to respond. There was a blank inter-trial interval of 1000ms, at which point the mouse returned to the centre of the screen so that the position from which the mouse was moved in each trial was consistent. The stimuli were presented in a random order and participants were unable to self-correct errors. The computer program used to present the stimuli recorded response times and response accuracy per letter string.

2.4 Statistical analysis

In order to remove the influence of anticipatory responses or attention lapses from reaction time data, responses faster than 150ms and those that deviated more than 3 standard deviations from the mean per condition for each participant were excluded from analysis. As a result, 7.76% of the data was removed, which is within the recommended range for data

analysis (Ratcliff, 1993). Mixed analysis of variance was used to explore the effects of group (two levels: aphasia, control) and valence (three levels: positive, negative, neutral) on accuracy and response time in the lexical decision task. We also explored possible relationships between severity of aphasia and performance in the aphasic group. Because severity only impacts aphasic participants, accuracy and response time for this group only were submitted to subsequent additional analyses of covariance (ANCOVA) using aphasia quotient (AQ) as a covariate. Where severity was found to interact significantly with performance we followed this up by examining the regression coefficients for severity in relation to each of the valence conditions (positive, negative, neutral). As the regression coefficient is a measure of the strength of influence of one variable upon another, this provided us with an indication of the impact of severity on performance in the three valence conditions.

3. Results

3.1 Accuracy

Table 2 presents mean accuracy rates for each valence type for both groups. The ANOVA revealed that those with aphasia performed significantly less accurately than control participants ($F_{(1,38)}=6.12$ $p=.02$ $\eta_p{}^2=.14$). There was also a significant main effect of valence ($F_{(2,76)}=4.96$, $p=.009$ $\eta_p{}^2=.12$). We followed this up with pairwise comparisons using a Bonferroni correction for multiple comparisons, which showed that across the full sample accuracy was significantly higher for words with positive valence than for negative and neutral valence (both $p=.021$). A significant interaction was found between emotional valence and group ($F_{(2,76)}=3.99$ $p=.023$ $\eta_p{}^2=.10$). Follow-up analyses with pairwise comparisons using a Bonferroni correction for multiple comparisons revealed that for the aphasic group positive words were identified as words more accurately than neutral words ($t(19)=2.56$,

p=.019, d=.349). The difference between positive and negative stimuli had a moderate effect size and showed a trend towards significance (t(19)=2.10, *p*=.049, d=.295). There was no significant difference between negative and neutral words (*p*=.65). For the control participants no differences were found between valence types (negative-neutral, *p*=.096; negative-positive, *p*=.214; positive-neutral, *p*=.330).

Insert table 2 about here

When analysis of covariance (ANCOVA) was conducted using aphasia quotient as a covariate for the accuracy scores in the aphasic group, aphasia severity was found to be a significant covariate (F(1,18) =13.01, *p*=.002, η_p^2=. 42). The difference between valence conditions for the group remained significant (F(2,36)=7.61, *p*=.002, η_p^2=.30). Pairwise comparisons revealed that without the confounding effect of severity, scores for positive items were significantly better than both neutral (*p*=.014) and negative items (*p*=.021), and there was no difference in performance between negative and neutral words (*p*=.627). There was also a significant interaction between valence and severity (F(2,36)=6.07, *p*=.005, η_p^2=. 25). In order to explore this interaction we examined the regression coefficients for aphasia severity in relation to each of the three valence conditions (positive, negative and neutral words). These provided an indication of relative improvements in accuracy corresponding to aphasia quotient scores. The regression coefficients indicated that although those with more severe aphasia (lower aphasia quotient) made more errors than those with less severe aphasia with all three types of word, aphasia severity appears to have had a less marked impact on performance with positive words (β=0.11, *p*=.004; i.e. an increase in accuracy of 0.11 for each increase of one point on the aphasia quotient), than neutral (β=0.17, *p*=.004) and negative words (β=0.2, *p*=.001).

3.2 Response time

Analysis was carried out on correct responses only. Table 2 shows mean response time for each valence type for both groups. The ANOVA revealed a main effect of group: the participants with aphasia took significantly longer than the control group to respond ($F(1,38)=21.33$, p<.001, $\eta_p^2 =.36$). The effect of valence was also significant ($F(2,76)=7.67$, p=.001, $\eta_p^2 =.17$): overall participants responded more slowly to neutral stimuli than both negative and positive words (*p*=.007, *p*=.001, respectively). There was no significant difference between negative and positive words (*p*=.272). Though the interaction between group and valence was not significant ($F(2,76)=2.36$, p=.10, $\eta_p^2 =.06$), planned comparisons revealed different patterns in response to valence type in the two participant groups. Participants with aphasia responded significantly more quickly to words with both positive ($t(19)=2.67$, *p*=.015, d=.259) and negative valence ($t(19)=2.49$, *p*=.022, d=.197) than neutral words, but there was no difference between the polarities ($t(19)=.528$, *p*=.604, d=.132). In contrast, control participants responded significantly more quickly to words with positive valence than both negative ($t(19)=2.36$, *p*=.029, d=.136) and neutral words ($t(19)=3.11$, *p*=.006, d=.232), but no difference between negative and neutral words ($t(19)=1.667$, *p*=.110, d=.392).

ANCOVA was also used to determine whether people with different levels of aphasia severity performed differently in the different valence conditions. This analysis showed the main effect of valence was not significant ($F(2,36)=.17$, *p*=.85, $\eta_p^2 =.01$). Planned comparisons, however, mirrored findings from the ANOVA, revealing faster response times for words with both positive (*p*=.018) and negative valence (*p*=.026) than neutral words, and no difference between valence types (*p*=.661). Aphasia severity (as measured by aphasia

quotient) was not a significant covariate ($F_{(1,18)}$=.10, p=.76, η_p^2 =.01) and there was no interaction between valence and severity ($F_{(2,36)}$=.15, p=.87, η_p^2 =.01).

4. Discussion

The aim of the current study was to determine whether emotional valence (i.e. valenced words vs neutral words) has an impact on word recognition in adults with aphasia, using stimuli carefully controlled for a wide range of other psycholinguistic variables, and as compared to a group of control participants matched for age, gender and education level. The study sought additionally to determine whether the polarity of items (i.e. negative vs positive valence) influenced performance.

Participants with aphasia performed significantly less accurately and more slowly than control participants, which is in line with previous studies using lexical decision (e.g. Moreno, Buchanan & Van Orden, 2002). Our experiment also demonstrated a processing advantage for words with emotional valence over neutral words. This mirrors previous research with both neurotypical adults (Estes & Adelman, 2008; Yap & Seow, 2014), including Kousta et al (2009) whose experiment we partially replicated with our participants, and with adults who have aphasia (Berrin-Wasserman et al, 2003; Landis, 2006; Reuterskiöld, 1991). In the aphasic group this advantage was observed in both accuracy and response time. When we examined the effect of polarity on responses, we found that both groups showed an advantage for positive stimuli. For the aphasic participants (after controlling for aphasia severity) this was observed in accuracy scores: positive stimuli generated significantly fewer errors than both negative as well as neutral words.

The findings of this study have important implications for aphasia research and clinical work since deficits in lexical access are very common in individuals with aphasia (Laine & Martin, 2006) and are frequently targeted in therapy (Nickels, 2002). In addition to

confirming that emotional valence has a facilitative effect on lexical retrieval in aphasia, ours is the first study in which the stimuli allowed us also to detect an additional effect of polarity on processing, namely that this group were more accurate in response to words with positive valence than both negative and neutral words. This indicates that valence should be considered, along with other psycholinguistic factors such as frequency and imageability, in the selection of items used in the assessment of lexical retrieval deficits in aphasia, for example so that sets (i.e. treated vs untreated items) are well matched. Further research is needed however in order to disentangle the contribution of valence to processing relative to other psycholinguistic variables.

Our study findings could also be exploited in therapy so that individuals with aphasia experience success by working with word sets which are likely to enhance performance. Semantic therapy approaches, in particular, may be more effective for items with emotional valence. A facilitative effect of semantically rich items was observed in research carried out by Conroy and colleagues (2012) who explored the relationship between the responsiveness of individual words used in cueing therapy and the psycholinguistic properties of those words. They found a marked effect of imageability, that is that highly imageable words were more likely to be named accurately after therapy. A similar approach (i.e. comparing valenced words to neutral words) could be applied to any therapy approach which has been demonstrated to be effective for single word naming (e.g. repetition, naming to definition) and incorporates abstract items. Though the implications are most obvious for semantic therapies, there may be broader implications for a range of approaches targeting different levels of breakdown. Howard and Gatehouse (2006) provide evidence that imageability has an impact on other levels of breakdown in addition to the semantic level; they found effects with post-semantic impairments (e.g. difficulties in mapping between semantics and phonology). If this is true for imageability it may also hold for valence.

We found that severity of aphasia, as measured by the aphasia quotient from the Western Aphasia Battery, was a significant covariate in our analysis of accuracy and there was a significant interaction between severity and valence. Inspection of regression coefficients indicated that severity of aphasia had a marginally less marked impact on accuracy of response with positively valenced words than it did for performance with neutral and negative words. It may be that individuals with more severe aphasia perform best with words with positive valence in particular and this information could be incorporated into their treatment plan. If this is the case, it would seem to support the proposition of Howard and colleagues (1995) that semantically richer presentations (in this case reflected in valence) are more resistant to brain damage. We used opportunity sampling in the current study, and though there was variation in our sample in terms of type and severity of aphasia, 15 of our 20 participants had anomic aphasia. Further research, exploring severity systematically, could uncover whether there are individuals who benefit most from emotionally valenced stimuli.

Whereas in the aphasic group the facilitatory effect of valence was observed in both accuracy and response time, in the control group this was only evident in the response time measure as accuracy scores were at ceiling. Given that Kousta and colleagues (2009), using the same stimuli, found a significant effect of valence on accuracy, we did not expect our participants, who were older than those in the Kousta study, to perform at ceiling on this task. However, ours is the not the first study to observe that a ceiling effect masks the impact of psycholinguistic variables that only become evident when response time is considered (see, for example, Nickels & Cole-Virtue, 2004). In addition, the response times for our control participants were three times longer than those recorded in Kousta's study, and those of the aphasic participants often markedly longer. The dissimilarity in terms of accuracy with the Kousta study may therefore reflect a different approach to the task taken by our participants who may have made decisions more slowly in order to avoid errors, thus providing more

accurate but slower responses. In contrast, some younger adults have been observed to balance speed and accuracy rather than minimise errors at the expense of speed (Starns & Ratcliff, 2010).

An effect of polarity was also observed in both groups: for aphasic participants this was evident in accuracy scores, but for the neurotypical controls response times were significantly quicker for positive than negative as well as neutral stimuli. Previous experiments have reported a facilitative impact of positive stimuli in neurotypical adults. In a study exploring semantic priming in neurotypical adults, Topolinski and Deutsch (2013) reported that stimuli with emotional valence (both positive and negative) induced very brief (positive or negative) emotional states in their participants which varied from trial to trial (a phenomenon which they call 'phasic affect modulation'). The authors argue that brief affect inductions impacted the priming of subsequent words, but that the effect for positive affect was larger than negative affect. It has been suggested elsewhere that positive affect has a facilitatory influence on cognition and behaviour (e.g. Ashby, Isen & Turken, 1999). This may account for the effect observed here in our two groups: valenced stimuli induced brief affective states which enhanced processing but the effect was significantly greater for positive than negative stimuli. Alternatively, the 'positivity effect' may have arisen because words with positive valence have a lower response threshold (i.e. the quantity of activation needed to trigger a neural response) and therefore may be processed more quickly (Kuperman et al., 2014).

These tentative explanations, however, cannot by themselves account for the fact that with identical materials, participants in the current study showed a 'positivity effect' whereas Kousta and colleagues (2009) found no effect of polarity on their results either on accuracy or response latency. There are two key differences between the present study and that of Kousta. First, in the current study our participants responded using a computer mouse, whereas in the

Kousta study participants used a keyboard to register their responses. We selected the different means of response in order to best accommodate the group who were of central interest to us: those with aphasia. The research user group in our clinic – consisting of individuals with aphasia – have indicated a preference for the mouse over the keyboard in experiments as the latter requires either two hands or two distinct responses with one hand, which adds unacceptable processing demands to tasks. These demands increase all the more when participants use their nonpreferred hand to respond (because of hemiparesis affecting their preferred hand). In our aphasic group, eight participants responded using their nonpreferred hand (see table 1), though all were experienced using their nonpreferred hand to interact with a computer, and we found no evidence that this subgroup performed any differently from the rest of the aphasic group. Moreover, the mouse is arguably a more natural – and therefore ecologically valid – means of response than the keyboard and it allows participants to keep their eyes fixed on the screen (McPherson & Burns, 2005). However, use of the mouse may have introduced additional variance due to varying psychomotor abilities and therefore the response time results should be viewed with appropriate caution.

An alternative explanation for the differences between the polarity findings of Kousta et al (2009) and the current study relates to the age of the participant groups included. The mean age of control participants in our study was 64.6 years (range = 34-81, including 15 people aged 60 or over) whereas the mean age of participants in the Kousta study was 19.15 years (standard deviation = 2.58). The aphasic group were aged between 36 and 83 years (mean = 61.5) with nine of the 20 individuals aged 60 or over. A positivity effect has been widely reported in research with older adults (aged 60+), where this group (relative to younger adults) prefer positive over negative information in experiments relating to attention and memory (e.g. Mather & Carstensen, 2005; Mikels, Larkin, Reuter-Lorenz & Carstensen, 2005). It has been argued that the findings of those experiments fit within the framework of

socioemotional selectivity theory (Reed & Carstensen, 2012) in which it is proposed that a set of social goals motivates behaviour throughout life and that, as time horizons narrow with aging, people focus increasingly on goals related to emotional satisfaction. This focus, it is claimed, has an impact on information processing so that older people attend to and remember positive information better than younger adults. The proposed difference between generations could therefore account for differences between our participants and the individuals who took part in the Kousta et al (2009). In their review of research exploring the age-related positivity effect, Reed, Chan and Mikels (2014) comment that further research, including longitudinal and sequential studies, could usefully address questions about changes related to the positivity effect across the lifespan.

In sum, this study shows that the emotional tone of a word has a significant effect on word recognition in people with aphasia, and is therefore an important factor to consider in assessment and intervention in aphasia. Future research, for example employing ERP to specify the temporal and spatial loci of emotion processing in people with aphasia, may be valuable in identifying whether the right hemisphere is engaged more in these tasks, with potentially powerful implications for rehabilitation work with this group.

Disclosure of interest

The authors report no conflict of interest.

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Table 1. Background information for participants with aphasia.

ID	Age	Gender	Months post-stroke	Hand used for experiment[a]	Years of education[b]	Profession	Aphasia Type	Aphasia Quotient
P1	36	Male	31	Left (NP)	16	Editor	Anomic	89.3
P2	47	Female	27	Left (NP)	11	Administration	Conduction	69.8
P3	50	Female	75	Right	11	Administration	Conduction	61.2
P4	50	Male	61	Left (NP)	16	IT consultant	Anomic	74.5
P5	53	Female	15	Left (NP)	11	Hairdresser	Anomic	85.4
P6	54	Male	91	Right	11	Driver	Broca's	80.4
P7	57	Male	43	Right	11	Upholsterer	Anomic	90.1
P8	57	Female	83	Left (NP)	16	Solicitor	Anomic	82
P9	58	Female	81	Right	11	Chef	Anomic	90.7
P10	58	Male	144	Left (NP)	16	Politician	Conduction	46
P11	59	Female	55	Right	16	Designer	Anomic	87.2
P12	64	Male	113	Right	16	IT consultant	Anomic	87.3

P13	67	Male	45	Left (NP)	11	Electrician	Anomic	91.9
P14	67	Male	201	Right	16	Solicitor	Transcortical	82
P15	67	Male	63	Left (NP)	16	Accountant	Anomic	80.9
P16	70	Female	108	Right	11	Scientist	Anomic	86.7
P17	70	Female	135	Right	16	Solicitor	Anomic	96.2
P18	79	Male	52	Right	16	Administration	Anomic	96.8
P19	81	Female	31	Right	13	Estate agent	Anomic	87.1
P20	83	Female	83	Right	11	Administration	Anomic	94.3

Note: Aphasia Quotient and aphasia types from WAB-R (Kertesz, 2006)

[a] NP = non-preferred hand

[b] Children start school at the age of 5 years in the United Kingdom.

Table 2. Means (and SD) for accuracy (max score = 38) and response time (in ms) for each participant group and condition

| Group | Valence | | | | | |
| | Positive | | Negative | | Neutral | |
	Accuracy	Response Time	Accuracy	Response Time	Accuracy	Response Time
Participants with aphasia	36.85 (2.18)	2417.07 (674.75)	35.95 (3.72)	2453.32 (860.90)	35.85 (3.41)	2634.20 (974.05)
Control participants	37.95 (.22)	1549.54 (306.06)	37.75 (.64)	1592.44 (326.61)	38 (.00)	1624.81 (341.84)