The Reading Strategies of People Who Stutter (PWS):

Do PWS use Grapheme-Phoneme Conversion disproportionately more than People who do not stutter?

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Abstract:

People Who Stutter (PWS) have been shown to have divergent abilities in comparison to People who do not stutter (PNS), across a number of linguistic tasks not directly linked to the physical symptoms of stuttering s, such as; non-word repetition (Hakim & Bernstein Ratner, 2004; Ludlow, Siren & Zakira); picture naming (eg. Anderson & Conture, 2004; Hennessey, Nang & Beilby, 2008) and reading (Bakker, Brutten, Janssen & Van Der Meulen, 1991; Bosshardt, 1990; Bosshardt & Nanydal, 1988). The current study proposes that people who (like PWS) find verbal communication difficult ('CD' group) use grapheme-phoneme conversion disproportionately more during reading than those that do not ('CE' Group). To explore this prediction a silent reading eye-tracking paradigm was used. Participants silently read 60 experimental sentences featuring a target place name. By manipulating the frequency (high, low and zero) while taking reading time measures it is hoped to highlight time course differences between the groups, consistent with different route usage on the basis of the Dual-Route Cascaded model (Coltheart, Rastle, Perry, Langdon and Ziegler, 2001). The results of this study revealed no significant differences in reading strategy between groups.

The Reading Strategies of People Who Stutter (PWS): Do PWS use Grapheme-Phoneme Conversion disproportionately more than People who do not stutter?

1. Introduction

“Traditionally, stuttering has been viewed as a disorder in which the ‘rhythm’ or fluency of speech is impaired by interruptions or blockages.” (Bloodstein & Ratner, 2008). However, there is a range of behaviours that have become associated with stuttering and Person(s) Who Stutter (PWS).

The general prevalence of stutterers amongst adults is placed at around 1%, although variation falls on both sides of this figure based on study and geographical location (Bloodstein & Ratner, 2008). There is an increased incidence rate amongst children which stands at around 5% (Bloodstein, 1995), which falls to the lower level with increased age. The age on onset can vary dramatically from co-occurring with the a child’s first attempt at saying to say sentences usually at around 2.5 years old, to a much later onset of stuttering like disfluency at 9 years of age, however, the younger end of the scale between 2-5 is the most common onset age (Bloodstein & Ratner, 2008). In children stuttering the recovery rate varies between studies, with estimates ranging from 36% -79% for different studies (see Bloodstein & Ratner, 2008, p86-87 for details). Primarily, a PWS is identified by the auditory disfluencies that give ‘stuttering’ its name, which consists of blocks, repetitions and prolongations. There are also many ‘secondary’ symptoms associated with the disorder that can have a large impact on the life quality of PWS. The first of these associated symptoms is the physical behaviours that often co-occur with stuttering, such as: tension in the jaw; facial grimaces; distracting sounds; vocal abnormalities and movement of extremities (as noted in the SSI-4; Riley, 2009). The cause of these physical concomitants is a response to the challenges faced by PWS in trying to produce fluent speech, rather than underlying motor-control issues (Bloodstein & Ratner, 2008). There are a number of other less common physiological concomitants, such as non-normal eye movements during stuttering events (Kopp, 1963) and include the feeling of frustration at the effort associated with speaking, the feeling of upcoming difficulty and the tension in the muscles associated with speaking (Bloodstein & Ratner, 2008). ‘Secondary’ symptoms also apply to deliberate strategies PWS adapt to control, mask, minimise and cope with stuttering behaviours, such as avoidance of troublesome words which lead to disfluency, avoiding situations which cause unnecessary anxiety and stress as this has been noted to cause higher levels of stuttering (Sheehan, 1953). Klein and Hood (2004) provided evidence of the effects stuttering can have on everyday life, their study showed that 70% of the 200 adults tested thought that stuttering limited career prospects and 20% reported stuttering as a reason for turning down new jobs or career progression.

PWS have also been shown to have divergent abilities in comparison to People who do not stutter (PNS), across a number of tasks not directly linked to the physical symptoms of stuttering, including linguistic tasks, such as; non-word repetition (Hakim & Bernstein Ratner, 2004; Ludlow, Siren & Zakira, 1997); picture naming (eg. Anderson & Conture, 2004; Hennessey, Nang & Beilby, 2008) and reading (eg.Bakker, Brutten, Janssen & Van Der Meulen, 1991; Bosshardt, 1990; Bosshardt & Nanydal, 1988). Previous studies have shown elevated reading times for PWS (Bakker et al., 1991; Bosshardt, 1990; Bosshardt & Nanydal, 1988). The question of why PWS show differential reading behaviour forms the focus of the current study. The present paper suggests that a possible cause for the longer reading times demonstrated could be attributed to a difference in reading strategy between PWS and PNS. The purpose of the current study is to explore why PWS demonstrate slower reading, focussing on their reading strategies to see if there is divergence from the behaviours demonstrated by PNS. Also, it is hoped to distinguish between two possible causes for different reading strategies: the first possibility stems from the childhood development of PWS, Due to the anxiety associated with reading aloud CWS may have practised less than normally fluent peers, leading to a lasting deficiency in their reading ability; the second cause is difficulty in formulating speech plans.

To address this question, we first, review linguistic theories of stuttering and outline the linguistic deficits which have been linked to stuttering. We then review evidence of reading deficits in PWS. Finally, we present a more thorough outline of the current study and the predictions of the study using the Dual-Route Cascaded model of reading as a basis (Coltheart, Rastle, Perry, Langdon and Ziegler, 2001).

1.1 Causes of Stuttering.

There is still no clear etiology for the disorder, although the most prominent theories fall into one of two categories: the first being a motor control issue being the cause of stuttering; the second being a psycholinguistic explanation. These varying views place the locus of stuttering at different stages of language production.

The Motoric view states that crucially there is not an impeded or incomplete speech plan, stuttering is caused by a deficiency in the motor control associated with the coordination of processes that execute the speech plan and create fluent speech. Evidence for a motor control based theory of stuttering is shown by divergent measures of articulatory processes between PWS and PNS (eg. Kleinow & Smith, 2000) increase in fluency for whispered speech for PWS (eg. Perkins, Rudas, Johnson & Bell, 1976) and slower initiation of speech movements for PWS compared to PNS (eg. Logan, 2003, van Lieshout, Hulstijn & Peters, 1996). There are a number of theories as to where and how these deficiencies are realised with the speech motor system, including: speech motor planning (Venkatagari, 2004); preparation or execution of muscle command (van Lieshout et al., 1996) and integration issues arising between segmental plans and the prosodic requirements of speech (Packman, Onslow, Richard & Van Doorn, 1996.)

Competing psycholinguistic views locate the cause of stuttering within the formulation of speech and as a deficiency in a type of linguistic based process used to create a speech plan. Crucially, the issue arises before the speech motor system. The physical symptom of stuttering would then be a reaction by the speech motor system, as it tries to cope with impoverished input (eg. Howell & Au-Yeung, 2002; Bosshardt, 2006; Postma & Kolk, 1993).

Linguistic encoding, (syntactic, semantic, lexical or phonetic) is well cited as a possible deficiency that could cause stuttering, (eg. Postma & Kolk, 1993; Vasic & Wijnen, 2005; Howell & Yeung, 2002). One of the most prominent psycholinguistic models of stuttering is the Covert Repair Hypothesis (Postma & Kolk, 1993), which states that the general cause of disfluency for both PWS and PNS is the detection and repair of errors in the speech plan before the onset of articulation. PWS are more disfluent than PNS because slow or inefficient phonological encoding predisposes them to producing speech plans that contain a disproportionately high number of encoding errors leading to a similarly high number of repairs.

The ‘Vicious Circle’ hypothesis proposed by Vasic and Wijnen (2005) builds on the CRH, keeping support that stuttering events are caused by covert repairs. However, it states that for PWS, instead of making a higher number of phonological encoding errors they have an increased sensitivity to internal errors coupled with a lower ‘threshold’ at which an error repair is undertaken. In Vasij and Wijnen (2005) support for this hypothesis is shown by dual-task paradigm which took resources away from the monitor with an unrelated task. Therefore, due to the decrease in resources for the monitor speech should become more fluent as fewer errors are detected in the speech plan. Their results provided evidence in support of their hypothesis.

The EXPLAN hypothesis (Howell & Au-Yeung, 2002), also theorises that stuttering arises in the speech plan, but rather than stuttering arising due to a disproportionately high number of internal phonological encoding errors it states that stuttering like disfluency occurs when the speech planning rate is not sufficient to match what is being produced, leading to repetition of previous speech plan until a new plan can be formulated.

1.2 Evidence for linguistic deficits in PWS.

Studies have shown that stuttering appears to be affected by linguistic factors, such as PWS are more likely to stutter on complex grammatical structures (Kadihanifi & Howell, 1992; Melnick & Conture, 2000). Hennessey et al., (2008) used auditory priming during picture naming tasks to show there was a lack on difference between PWS and PNS for both semantic and phonological conditions, suggesting comparable encoding abilities between groups. Anderson and Conture (2004) tested the syntactic encoding abilities of CWS in a picture description task. In one condition, participants received priming from an utterance of the syntactic structure needed to accurately describe the picture. In the other condition, a different syntactic structure to the one required to be used was heard. For the priming condition, CWS showed increased syntactic priming, as the group differences narrowed from the non-priming condition. This was suggested to show inefficiency in the CWS' syntactic encoding. Similar results were shown by Tsiamtsiouris & Cairns (2009) providing more evidence for this hypothesis. Pellowski and Conture (2005), showed that CWS (children who stutter) demonstrated an onset latencies increase when subject to semantically related primes, compared to the CNS control group, where the naming latency decreased. This study would suggest that CWS show a greater interference effect stemming from a divergence in linguistic encoding ability for CWS compared to controls.

Further evidence for decreased encoding abilities comes from Brocklehurst and Corley (2011), who demonstrated that PWS made significantly more inner speech errors than the PNS group. They used this to frame the question of support for the CRH. Their results support the CRH theory of PWS making a disproportionately higher number of internal encoding errors (tenet 1). However, they also found that PWS' inner-speech errors did not correlate with their measured disfluency rates. This goes against the second tenet of the CRH which states that these errors are the cause of all stuttering events.

1.3 PWS Reading Studies.

There is mounting evidence that for both reading aloud and silent reading tasks PWS read more slowly than PNS. Bakker et al. (1991) tested the anticipatory abilities of school age children to predict which words they would stutter on with a number of tests that included a silent reading eye-tracking task. Their results showed that during the silent reading task the children fixated significantly longer on words which they later had trouble producing fluently, when asked to read aloud following the eye-tracking . This mirrors what is seen in a normally fluent population (PNS) as seen in Rayner and Pollatsek (1989). Bosshardt and Nandyal (1988) set out to compare both the silent and reading aloud abilities of PWS and PNS in a word list based study. The results highlighted that PWS showed longer reading times per syllable and word, for both the silent and aloud condition when reading. Word length was also shown to demonstrate an effect on the PWS participants when reading aloud, with words with more syllables taking proportionally longer than for those words with less syllables. For silent reading, a similar phenomenon was demonstrated bordering on a significant level (p= 0.053). This study provided evidence that there a clear link exists between word length and elevated time course for PWS participants, suggesting that PWS have increased reading times for longer words when compared against shorter words. This effect has also been noted in PNS populations (Inhoff & Rayner, 1986; Rayner, Sereno & Raney, 1996).

However, for this study there was additional pressure placed on the PWS by the experimenter's instructions that they had to read as quickly as they could (Bloodstein & Ratner, 2008). This has been shown to increase stuttering events (Caruso, Chodzko-Zajiko, Bidinger & Sommers, 1994) questioning the validity of the experiments findings. Another criticism and potential flaw with this research is the use of a manual reaction element involved in the study. There is evidence in the literature that suggests that PWS have increased manual reaction times, with Luper and Cross (1978) and Prosek, Montegomery, Walden and Schwarz (1979) demonstrating positive evidence of elevated reaction times. Therefore, Bosshardt and Nandyal's effect could stem from increased time taken due to the manual reaction process of pressing the button to move to the next item, instead of the causation being linked to elevated reading times. However, there have also been studies where PWS' increased manual reaction times have not been found significant across a range of PWS (Borden, 1983). However, this study did show increased times for severe PWS, although more of the variance from the PNS control group was from task related effects, but for PWS with mild stuttering severity there was no significant difference from the control group.

More recently, Sasisekaran, De Nil, Smyth and Johnson, (2006) and Sasisekaran and De Nil, (2006), have shown no disparity between PNS' and PWS' performance on simple motor tasks during a phoneme-monitoring study. Therefore it remains unlikely that the effect noted in Bosshardt and Nandyal (1988) is completely based on differences in motor reaction time between PWS and PNS. The task for Bosshardt and Nandyal's (1988) experiment was centred on reading a word list, which lacks ecological validity, as the majority of reading that language users undertake on a daily basis is presented as sentences and discourse. Similar results to this study were demonstrated in a population of CWS, showing that they took longer to read a word list than the CNS control group (Bosshardt, 1990).

1.4 Current study.

It has been shown that PWS show elevated reading times during reading. Why is this? One possibility is that slow reading is due to slow phonological encoding. A second possibility is because when they were young children they avoided speaking and so never got much practice reading aloud, and so failed to develop as high a level of proficiency as fluent children who generally enjoy speaking and reading aloud. The current study aims to distinguish between these two possibilities. For practical reasons, we had to change the primary focus of the study away from an SSI-4 based PWS/PNS split due to a lack of PWS participants available during the timescale. Therefore, instead of comparing the reading strategies of PWS and PNS, in this study we compare the reading strategies of people who (like PWS) find verbal communication difficult: the 'Communication Difficulty' (CD) group (who for the purpose of the current study can be thought of as pseudo-stutterers), with people who find it easy: the 'Communication Easy' (CE) group. To do this, we make use of a silent reading eye-tracking paradigm. It was important to use silent reading, as previous studies have demonstrated a difference in eye-movements between silent and oral reading in PNS populations (Rayner, 1998), therefore, for the current study reading aloud could have caused the PWS participants data not to reflect normal reading strategies. Participants silently read 60 experimental sentences featuring a target place name. All target place names featured in a pre-test of familiarity. By manipulating the frequency (high, low and zero) and familiarity of target place names presented in a sentential context and measuring first pass, regression path and total time spent in the critical zone of the target items it is hoped to highlight a difference in reading strategy which will be realised as time course differences shown between 'CD' ' and ''CE' ' groups across frequency conditions. Eye-tracking has the advantages of not being tainted by manual reaction times, as in this paradigm, although the participant has to press a button for the next experimental to be presented, it has no effect on the eye-tracking variables being measured as these fall in the critical region and no general measure of time taken to read the sentential context is employed. Rayner and Pollatsek (1989) showed that for a fluent population difficulty with a word can result in more fixations, longer fixations and an increased number of regressions back to the target word. With the current paradigm all of these measures are being monitored so will provide an excellent overview of the behaviours exerted by the 'CD' and ''CE'' both groups. Participant's fluency was measured using the SSI-4 test (Riley, 2009) in order to obtain a reliable PWS group, although there was difficulty in recruiting in the PWS population (reported later in the Method section). The difference in reading strategy will be motivated from the different routes available in the Dual Route Model of Coltheart et al. (2001) which form the basis for predictions made.

1.5 Predictions for PWS/ PNS reading using The Dual-Route Cascaded Model.

Coltheart et al. (2001) proposed a dual-route cascaded model (DRC) for reading, that states that for reading there are two possible pathways: lexical (which is sub divided into lexical semantic and non-lexical semantic); and non-lexical.

These three sub-routes facilitate word-retrieval and successful reading using two different strategies: one strategy ('whole-word' strategy) for known lexical words which have an entry in the readers mental lexicon, (whether or not there is phonological and semantic information held for this entry); and a second strategy (Grapheme-Phoneme Conversion) for words which do not have a lexical entry. The lexical semantic route would be the quickest route, followed by the non-lexical semantic route, with the GPC route proving to have the slowest time course.

Each route uses different processes to lead to the correct pronunciation of a target word, from a start point of visual word recognition of an orthographic stimulus through to word retrieval and suitable phonetic information being selected. The DRC model adopts a generalised version of the Interactive Activation (IAC) model (see Grainger & Jacobs, 1996; McClelland & Rumelhart, 1981) for the lexical orthographic processes employed during reading.

Starting with the lexical semantic route, the DRC model of Coltheart et al. (2001) states that when reading a word which readers have experienced enough to hold semantic knowledge, then word retrieval will be facilitated by a 'whole-word' or holistic approach. The word will be recognised as a whole orthographic entity linked to the lexicon entry and will lead to recognition in a quick manner, as a phonetic plan is already held, meaning there is no need for grapheme to phoneme conversion. In the context of the current study, the high frequency target words should be subject to this route of recognition, as the participants should have sufficient familiarity with the target place names to hold some semantic information and a mental lexicon entry. It is well attested in the literature that high frequency words lead to quicker access and production for both PWS (Newman & Bernstein Ratner, 2007; Prins, Main & Wampler, 1997) and PNS populations (Jescheniak & Levelt, 1994; Bien, Levelt & Baayen, 2006). Similar effects have been noted for PNS populations in silent reading; lexical familiarity and frequency having been demonstrated to effect processing times (Francis & Kucera, 1982); readers have also been shown to be quicker on words of high frequency compared to words of the same length that have a low frequency (Rayner e tal., 1996).

The lexical non-semantic route would be utilised when a reader has encountered a word but is not familiar with it, meaning that they hold a lack of semantic information associated with a lexicon entry which holds the orthographic and phonetic information. This level of familiarity would be expected for some low-frequency target items and the lower end of the high frequency target place-names for the current study. A 'whole-word' recognition approach would also be employed for this route. To demonstrate the difference between them, for a high frequency place name such as 'London' ,using the lexical semantic route, when read will activate a large amount of semantic knowledge associated with the concept such as, 'capital city of England', 'in the South East'. Phonological information, namely, the correct pronunciation of 'London' will also be activated. Whereas, for a lower frequency word, such as 'Shipley' which will use the non-semantic lexical route, little or no semantic information is held but the phonological is still available.

The GPC route is the final option in the DRC model (Coltheart et al. 2001) and would be employed when there is no lexicon entry present for a target stimulus. The main process used is a set of GPC based rules instead of the 'whole-word' strategy used in the lexical routes. This means that a phonetic plan is built up from visual information converted to single letter orthographic representations, which then uses the rules to map directly to a phoneme. Then it moves onto the next letter, which after being recognised ties the two-letter string to a phoneme if possible. If the string does not correspond to a phoneme the model ties the second letter to a separate phoneme. This route would be predicted to handle all the zero-frequency target items, as being non-words, the participants are highly unlikely to have any experience of the place names for this condition. A similar situation of participants having no familiarity with a number of the low frequency target items is likely, which will also lead to this route being utilised.

Due to the predictions about which routes of the DRC model the conditions of the target place names will make use of, further theorising about the determining the speed of recognition and reading times can be postulated.

First, if attention is focussed on the recognition and reading time of the single target word for the current study, then it would be proposed that if the route allocation of participants ('CD' & 'CE') during testing matches the predictions made above, namely that there will be variance of route used by the differing conditions between groups, summarised below in table 1, then this would affect the processing costs and time taken to read the target words in the differing conditions.

Table 1-

A Table showing the different predicted routes of the DRC Model for each condition of Target Word for the 'CE' versus 'CD' Groups- (The Primary/ Secondary distinction refers to the route for which the majority of that condition type is expected to use, compared to the minority, respectively.)

Group	Condition	Primary DRC Route Used	Secondary DRC Route Used
	High Frequency	Lexical Semantic Route	Lexical Non-semantic Route
'CE'	*Low Frequency*	**Lexical Non-semantic Route**	GPC Route
	Zero Frequency	GPC Route	NA
	High Frequency	Lexical Semantic Route	Lexical Non-semantic Route
'CD'	*Low Frequency*	**GPC-Route**	NA
	Zero Frequency	GPC Route	NA

For all participants, the high frequency condition should be relatively quicker compared to other conditions due to the use of the lexical-semantic route; this would be a repetition of well known frequency/ familiarity effects (Francis & Kucera, 1982, Rayner et al. 1996). The low frequency condition should also on average across the data set be quicker than the zero frequency due to a spread of route usage, with the majority of target items employing the lexical non-semantic route for and fewer target place names using the GPC route for the PNS group. The Zero frequency is expected to only make use of the GPC route so will be the slowest due to the additional time associated with this route. The crucial proposed differences are between the 'CD' and 'CE' groups. This is most likely to occur in the low-frequency condition where there is likely to be variance as the two groups would be predicted to take different primary routes for this condition. Due to the higher demands of the GPC leading to decreased speed, then if the difficult group do use this strategy disproportionately more than the easy group, as proposed for this study, it would result in elevated reading times as seen in previous data (Bakker et al., 1991; Bosshardt, 1990; Bosshardt & Nanydal, 1988). Although there is no reading aloud involved with the current task, it could still highlight differences in the speed of phonological encoding, as there is strong evidence for 'speech like' subvocalisation during silent reading (eg. Ashby & Martin, 2008). The results of this paper showed that readers activated detailed phonological information, including suprasegmental information that cannot be attained only from the orthographic representation available, during silent reading (Ashby & Martin, 2008).

1.6 Predictions for the Current Study

The target words are presented in sentences, as it represents a more naturalistic approach. However, the context of these sentential holders is identical across the three frequency conditions. Therefore, it should not affect the usage of the relevant route for each stimulus and if there were to be an effect it would be equally present across conditions.

A possible cause for a difference in reading strategy of PWS stems from childhood. CWS (Children Who Stuttter) have been shown to exhibit 'whole word' phonological encoding strategies during priming experiments comparably later to age matched controls. (eg. Byrd, Conture & Ohde, 2007), this study found that CWS at 5 years old were showing a comparable phonological strategy to a 3 year old control, whereas, the control group showed sensitivity to segmental strategies by this age. A decreased ability at non-word repetition is also reported for CWS (Hakim & Bernstein Ratner, 2004). As noted by Hennessey, Nang and Beilby (2008) on Badderley, Gathercole, and Papagno, (1998) non-word repetition ability is thought to demonstrate knowledge and the working memory capacity of phonological information. An argument could be made that due to the disfluent experiences of CWS; maybe they practice reading aloud disproportionately less compared to age matched fluent controls and this lack of practice leads to a decreased phonological knowledge or phonological working memory capacity or a slower learning curve, which is already apparent between groups by 5 years old, as demonstrated above (Byrd et al., 2007). For the current study, it would lead to the prediction that due to the decreased phonological encoding ability, we would expect the 'CD' group to show slower reading times across all conditions compared to the 'CE' group, although, we would still expect that the more familiar and higher frequency target words would be read quicker, due to the well attested to frequency effect (eg. Rayner et al., 1996). However, the 'CD' group should show equal magnitude of difference across conditions relative to this frequency effect, meaning that no condition should show a proportionately higher 'slow reading' effect.

As CWS mature, this slower learning or lower ability could lead to disparity between the word-reading strategies of PWS and PNS, meaning that even adult PWS show decreased abilities. Evidence supporting this view comes from PWS' decreased non-word reading even into adulthood (Ludlow, Siren & Zikira, 1997). This would be realised as PWS not employing the 'whole-word' route (lexical semantic and non-semantic lexical sub-routes in the DRC model, Coltheart et al., 2001) the same amount as the PNS control group. The reason being due to their lack of childhood practice, PWS have decreased 'holistic' word reading abilities, therefore, using the GPC route disproportionately more than the PNS group. This would lead to a different set of prediction than the phonological encoding theory outlined above. The predictions for the 'reading strategy' theory, proposed in the current paper, would suggest that there would be a proportionately larger magnitude of reading effect, most likely, in the low condition, as this is where the two groups would diverge in reading strategy, with the 'CE' group employing the 'whole-word' route and the 'CD' group using the GPC-route. It would also be predicted, that there would be some influence of phonological encoding as attested to in the literature (eg. Corley & Brocklehurst, 2011) leading to the 'CD' group being slower than the 'CE' group in each condition.

Both predictions singularly, or a mixture would implicate a psycholinguistic theory for the etiology of stuttering, as the deficiency is either with phonological encoding or the lexical retrieval strategy employed during reading or a contains elements of both, meaning the locus of the error is in the speech plan, and not motor control based. The implications for individual models are noted in the discussion.

1.61 Hypothesis:

'Participants with higher disfluency (SSI4) scores (or who self-report high levels of difficulty communicating and difficulty speaking fluently) use grapheme-phoneme conversion disproportionately more during reading than participants with lower disfluency scores.'

2. Method

2.1 Participants.

The current study aimed to have equal numbers of PWS (n=12) and PNS (n=12) to compare results between groups as with previous studies (eg. Postma & Kolk, 1992). However, this number of PWS could not be recruited. Due to the difficulties with recruitment, the number of self-identified PWS fell (n=6). The number of controls was increased (n=22). Instead of using SSI-4 fluency based rating to define a participants level of disfluency, the primary measure and focus of the study changed to the fluency difficulty (FLUDIF) and communication difficulty (COMDIF) self-rating scores from section 3a of the OASES (Yaruss & Quesal, 2006) that all participants filled out. Using these scores which had a possible range of 10 ('low' difficulty) to 50 ('High' difficulty), participants were split into two groups, one which showed communication difficulty 'CD' and the other which showed relative ease 'CE' group , using a median split based on scores (FLUDIF=>16 for 'CD'group, ≤16 for 'CE' group, COMDIF=>22 for 'CD' group, ≤22 for 'CE' group). All participants were native speakers of English. The PWS group (3 male) had a mean age of 35.7 years (range= 20-63). The PNS group (9 Males) had a mean age of 23.3 years (range=19-28). The groups were matched for Educational background. Mean Education Level (on a scale where 1-represented GCSE or equivalent and 5- represented Post-graduate degree), for the PWS group was 4.5 and for PNS was 4.3. PWS Participants were recruited in a number of ways. The first through contact with the Edinburgh Stammering Association, leading to an email with an online advert included being circulated to all members. The second method was an advert placed in the Edinburgh Evening News with a link to the online advert. A similar online advert was also placed on the University of Edinburgh careers website. The remainder of contacts were recruited by personal contact. The PNS control group was recruited through personal contact and through an online advert on the University of Edinburgh careers website.

2.11 Normal or corrected to Normal vision.

To check the vision of each participant was suitable the study, participants had to undertake a short eye-sight test, which required them standing at a fixed location and reading and reciting a number of letters. Also, if necessary, participants were instructed how to calculate their dominant eye using a simple test.

2.12 Stuttering Severity.

Each participant was tested using the Stuttering Severity Index 4 (SSI-4) (Riley, 2009) to measure their fluency in speech. The SSI-4 is a measure of how seriously stuttering affects an individual (Howell, 2011). Before undertaking the SSI-4 the participants had to complete a consent form. Then participants were seated in a quiet room and given instructions on how the test ran. The participants were then videoed reading aloud a passage of a known number of syllables and from this a percentage of syllables stuttered figure was recorded. A duration score for the three worst stuttering episodes (as rated on the SSI4 guidelines) was also calculated, this measure takes the three longest stuttering events in seconds and averages them leaving a mean time that is compared to the SSI-4 scale (Howell, 2011). This process was repeated for a short passage of spontaneous conversation between the experimenter and the participant. For the PWS the mean SSI-4 score= 14.75 (range=0-29). This included one member of the PWS who did not show any stuttering like disfluency during the all contact with the experimenters. She was kept in the PWS group as in previous studies; even those that have previously exhibited PWS like behaviour have shown divergent abilities from PNS (Bloodstein & Ratner, 2008). The control group did not exhibit any significant stammering behaviour as defined by the SSI4.

2.13 Fluency and Communication Difficulty Self-rating Questionnaire.

All participants completed an online questionnaire which featured Section 3a of the Overall Assessment of the Speaker's Experience of Stuttering (Oases; Yaruss & Quesal, 2006). This consists of completing 10 questions which ask the participants for a judgement on rating scale (1-5) of their current difficulty in verbal communication (COMDIF) for 10 commonly occurring situations. This set of situations was repeated, with participants asked to respond for “Fluency difficulty”, (FLUDIF) again giving a judgement on the same rating scale. Responses were collated and a score for each of these difficulties was obtained (range=10 (Low)-50 (High)). The distribution of these scores over all participants is shown below (Figure 1.)

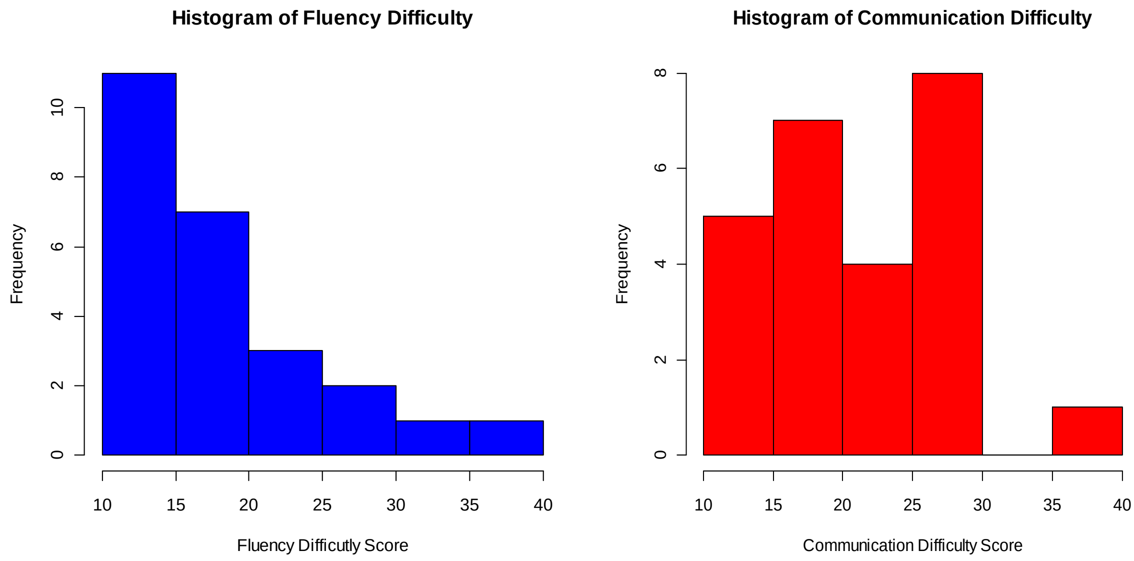

Figure 1

The scores of Participants for Fluency Difficulty and Communication Difficulty.

2.14 Dyslexia Screening test.

The participants also took a dyslexia screening test in the form of the Wide Range Achievement Test, Third Edition (WRAT 3; Wilkinson, 1993). The participants were asked to read aloud a number of target words in a set order from a pre-fabricated WRAT sheet. Any mistakes or difficulty which resulted in a divergence from the correct phonology were recorded. The results from this test showed comparable abilities between the PWS and PNS groups. All participants reported no additional speech, language, hearing or visual impairments that were likely to affect their results.

2.2 Materials.

Using the British National Corpus (BNC) a proper nouns subset of all those which featured in the larger corpus was created. From this subset 60 high and low frequency place name word pairs were selected to adhere to a number of criteria, the first being that the high frequency variant had a recorded frequency of 200 or above (mean 572.9 per 10 million). However, very high frequency place names such as capitals (eg. London, and Paris) were not chosen, as they may have created an irregularly strong time effect when read, due to their very high familiarity, (Rayner et al., 1996), meaning that they could enhance the effect of 'Condition' across frequency groups. The low frequency variants all had values of less than 50 (mean 17.2 per 10 million). All words that were selected had regular phonological to orthographic relationships. Another selection criterion was that the two words chosen bore a phonetic similarity and were matched (to as finer degree as possible) in syllables and length (eg. Lambeth/Lamborne). As longer words have been shown to affect first pass fixation time (Just & Carpenter, 1980) if the target place names were not matched for length, it could confound any frequency condition based findings, as the difference in reading times could be down to word length. We also did not use proper nouns of Scottish origin due to a possible interference pattern with the study being based in Edinburgh. The place names selected were not all of British origin, however, the frequency rating in the BNC would suggest some familiarity with these places, on a similar level to the other place names chosen for the study. After these word-pairs had been created a third variation was created which was a zero frequency (non-existent) word which resembled the other two place names along the same criteria as for the place name pairs selected from the BNC.

Table 2

Example Place Names

Number	**High Frequency>200**	**Freq.**	**Low Frequency>50**	**Freq.**	**Zero Frequency**	**Freq.**
1	Anfield	204	Anerley	45	Anstead	0
17	Hamburg	386	Hambury	15	Hambett	0
25	Lancaster	1159	Lanchester	53	Lancminster	0
47	Skelton	265	Skeldale	6	Skeldon	0
36	Norfolk	1412	Norham	17	Nortbury	0
54	Redcar	390	Redburn	29	Redstead	0

These matched word triplets controlled for frequency and number of syllables, this was important to limit the variance in the data stemming from variation in these factors which could have skewed the results. A number of example triplets are shown above, (Table 2).

These triplets were then pre-tested to show that higher frequency words were recognised as being more familiar than the low and zero frequency equivalents. Twelve questionnaires featuring all 180 place names and a familiarity rating scale running from 1 to 7, (1, unfamiliar- 7, Familiar) were given to native English speakers to complete. The results from this pre-test showed that there was a clear difference between the mean score for each group: 'High' (mean= 5.26); ' Low' (mean=1.68); 'Zero' (mean=1.37). The familiarity ratings for the target place names for each frequency condition were significantly different from the other conditions: ‘High’ to ‘Low’ (p <0.001); ‘High’ to ‘Zero’ (p <0.001 ‘Low’ to ‘Zero’ (p =0.005). Next a list of 60 sentences was drawn up to provide context for the target place name. The sentence length and number of words was kept relatively equal to ensure ease of reading between trials. The target never fell at either the beginning or end of these sentential contexts, as this has been shown to effect eye-movement behaviour (Rayner & Pollatsek, 1989). A list of the sentences used in the experiment can be found in the appendix (Section 1).

Simple comprehension questions followed a third of trials. This was to combat participants just reading the words on a superficial level without any type of depth of processing. Questions could only be answered with either a ‘yes’ or ‘no’. The comprehension questions were counterbalanced so that there were an equal number of both answers. An example of an experimental trial and corresponding question are seen below:

Example Trial and Question:

Trial- A teenage boy from Cheston broke the regional hundred metre record.

Question- Did the boy break the hundred metre record?

2.3 Apparatus and Procedure.

The experiment was run using an SR Research EyeLink II eye-tracker, using the ‘EyeTrack’ software from the University of Massachusetts (http://www.psych.umass.edu/eyelab/software/). The items were presented on an Iiyama HM204DTA Vision Master Pro514 22” Screen, set at a resolution of 1024 x 768 using 24 bit colour. The sentences were presented in 20 point Courier New font. Gaze location was measured at a rate of 500 Hz, with a refresh every 2ms. One degree of visual angle was equivalent to around 3.5 characters.

Participants were seated 75cm from the screen, with their head resting on a chin rest to minimise head movement during the experiment. To calibrate the eye-tracker the experimenter advised the participant to cover one of their eyes using a black patch. The experimenter then ran through the calibration process. This was repeated for both eyes until a suitable level of eye-location accuracy was achieved. Before all sentence trials a fixation rectangle appeared. This was to check that the eyes were still being tracked effectively. Recalibration occurred during the experiment if either the experimenter felt that the accuracy levels had decreased or the participant could not successfully trigger the fixation rectangle to move on to the sentence. To advance to the next item participants were instructed to press the

‘X’ button on a games console controller. To respond to the comprehension questions participants were instructed to use the trigger button which corresponded to the side of the correct answer, for example, the right trigger would always correspond to the ‘No,’ answer, which was presented on the right side of the screen. A Zoom Q3 portable video camcorder was used to record the participants for the SSI 4 testing.

2.4 Design.

Participants saw 80 experimental items, 20 of which were comprehension questions. Of the 60 experimental trials, 20 featured target place names which came from the high, low and zero frequency list. Participants viewed one of 3 conditions, each condition featured the same sentential context for each trial but across the 3 conditions the target place name was different, meaning that participants in different conditions never saw the same target words. The linked target words were presented in the same sentential across conditions. An example is shown below:

Example Materials across Conditions:

Condition 1-

Peter and his family wants to visit *Hampstead* to see the sights. (High Frequency Target).

Condition 2-

Peter and his family wants to visit *Hamstone* to see the sights. (Low Frequency Target).

Condition 3-

Peter and his family wants to visit *Hamstard* to see the sights. (Zero Frequency Target).

Experimental items were presented in a random order within their Condition, meaning that each participant saw the experiment items in a different order. However, the comprehension questions always followed the sentence that they referred to.

2.5 Analyses.

For the current study the following reading time measures were taken, they are defined below:

First-pass reading time- the length of time spent from the first instance of fixation made within the critical region to the first exiting of the region.

Regression path- the ‘first pass’ reading time with additional time spent during regressions back in to in the critical region.

Total time- The sum of all time spent fixating within the critical region.

For the present study, the critical region represented the area taken up by the target place name. There were a number of measures taken so a number of different reading strategies could be examined. It has been shown that frequency and familiarity can affect the first pass time course of a reader, as frequency exerts an effect on initial processing (Francis & Kucera, 1982). For the current study, where there is predictions made about the DRC routes used by different groups, this measure can give us a good idea of the initial time spent processing a target place name for each frequency condition. It has been shown that PWS readers have elevated reading times (eg. Bosshardt & Nanydal, 1988), so there would be an expected time course difference between both groups in the present study, with the 'CD' group showing slower first pass times.

However, the magnitude of difference between the first pass readings, for each 'Condition' is the crucial measure, as a difference in magnitude of first pass reading time between the 'CD' and 'CE' groups in any condition, most likely the 'Low' condition, would suggest a difference in route usage and ,therefore, reading strategy. Increases in Total-time and regression path time could highlight if a reader is struggling to integrate a target place name with phonological information, as these measures capture any regression(s) back into the critical zone. The current study aimed to test PWS versus PNS for differences in reading strategy. However, a suitable number of PWS could not be recruited, so the primary measure and focus of the study changed to the fluency difficulty and communication difficulty self-rating scores from section 3a of the OASES (Yaruss & Quesal, 2006).

The range of data for both fluency and communication difficulty had a skew towards the lower end of the scale (possible range= 10-50), as can be seen from the histograms above (Figure 1) for Fluency Difficulty (FLUDIF) and for Communication difficulty (COMDIF). This was expected, as there was a much higher number of PNS (n=23) compared to PNS (n=6) and lower fluency and communication difficulty scores would be predicted for the PNS group. Using these scores which had a possible range of 10 ('low' difficulty) to 50 ('High' difficulty), participants were split into two groups, one which showed communication difficulty 'CD' and the other which showed relative ease 'CE' group , using a median split based on scores (FLUDIF=>16 for 'CD' group, ≤16 for 'CE' group, COMDIF=>22 for 'CD' group, ≤22 for 'CE' group).There was a significant difference between the 'CD' and 'CE' groups or FLUDIF (p <0.001). The same pattern was seen in the COMDIF split (p <0.001).

All PWS participants featured in the 'CD' group. Trials which included 2 or more blinks were excluded. At this stage, two of the PWS participants data was excluded from analysis as their data were very different from the data of the other participants. Fixations less than 80ms were merged into larger fixations around them automatically and fixations over 1200ms were also excluded. The first pass, regression path and total time data was extracted using custom made software.

Analyses were then carried out using linear mixed effects regression modelling using the lme4 package (Bates & Maechler, 2009) in R (R Development Core R Development Team, 2009). To start with a base model for each type of eye-tracking data (First Pass(FP), Regression Path (RP) and Total Time (TT)) was built using this as the output variable and had random intercepts for 'Participant' and 'Item'. Then the following predictor variables were added stepwise to each of these base models: Condition then either, Fluency Difficulty (FLUDIF) or Communication Difficulty (COMDIF), followed by the 'Condition by FLUDIF' or 'Condition by COMDIF' interactions. (FLUDIF and COMDIF were not entered into the same model due to co-linearity). Predictor variables were only retained if they significantly improved the fit of the model over the base model. At this step we found the 'best fit' model available with the data, where the addition of further predictors could not improve the fit of the model. A separate set of models were also built adding Familiarity Rating as a predictor instead of Condition.

3. Results

3.1 Comprehension Questions.

All participants scored over 70% or above on the comprehension questions that followed a third of the experimental items. The average across all participants was 94.8% (to 2dp) correct responses. There was minimal difference between the PWS mean (89.8%) and the PNS mean (96%), this did not reach significance (p=0.4).

3.2 Main Effects.

3.21 First Pass Analyses

Running the base model showed that the mean FP reading time was 335ms. The first predictor added to the FP base model was condition, as the predictions of the current study propose that there will be a frequency effect seen across conditions and a differential affect between 'CD' and 'CE' groups. Using an Anova analysis to compare the models, 'Condition' significantly improved the model (χ^2 (2)=43.25, p=<0.001). Here the difference shown in FP reading time, demonstrated by the intercepts of the model, is relative to the previous condition. The 'High' frequency condition= 273.58ms: with an increase of 57.85ms between the 'High' and 'Low' condition; with an increase of 69.27ms from 'Low' to 'Zero' condition; a cumulative effect of 127.12ms between the 'High' and 'Low' condition. As predicted repetition of well attested to frequency/familiarity effect across all participants (eg. Rayner et al., 1996). Unsurprisingly, the separate addition of 'familiarity rating' to the base model significantly improved the fit of the model (χ^2 (1)= 2728.5, p=< 0.001). The intercepts of this model showed that for each 1 point increase in familiarity rating it decreased the FP reading time by 8 ms. The 'familiarity rating' model shows the 'best fit' after adding one predictor, including a better fit than for 'Condition'. The predictions of the current study also state that there should be a significant effect of FLUDIF and COMDIF for the 'CD' and 'CE' groups. The other predictors do not further improve the model, (all χ^2 (1)= ≤ 0.1807, p= ≥ 0.6707).

Table 3-

A table that shows the 'Best Fit' models for each Eye-tracking Reading Time Variable.

Predictor	Estimate	Std. Error	*t*	*p*MCMC
First Pass reading time with Familiarity Rating as main predictor:				
(Intercept)	324.362	22.65	14.32	> 0.001
Familiarity Rating	-8.205	2.524	-3.251	0.0012
COMDIF	23.843	30.797	0.774	0.439
Regression Path reading time with Familarity Rating as main predictor:				
(Intercept)	447.737	38.474	11.637	>0.001
Familiarity Rating	-15.996	4.194	-3.814	>0.001
FLUDIF	-38.352	50.935	-0.753	0.4516
Total time with Familiarity Rating as main predictor:				
(Intercept)	527.717	47.728	11.057	>0.001
Familiarity Rating	-23.626	3.937	-6.001	>0.001
FLUDIF	-73.435	66.404	-1.106	0.269

Adding a valid second predictor did not further improve the model fit. However, due to the nature of question being focussed on 'disfluency', it was important to fit one of the difficulty predictors to the model to ensure thorough discussion of the results seen. Out of the two dependent variables, 'FLUDIF' and 'COMDIF', the latter relatively improved the model by the largest amount, which accounts for a tiny amount of variance overall. The results for this 'best fit' model can be seen in table 3. The *p*-values reported in this table use the "pvals.fnc" on R, which uses a Monte Carlo Simulation, indicated by the *p*MCMC title.

3.22 Regression Path Analyses.

The same pattern seen for FP reading time is seen for the RP output variable. Running the base model showed a mean RP reading time of 384ms. The Familiarity Rating ($\chi^2(1)$= 2855.8, *p*=<0.001) and Condition ($\chi^2(2)$= 27.191, *p*=<0.001) predictors significantly improve the base model when ran separately. The remaining predictors, again, accounted for little of the variance seen, for all ($\chi^2(1)$=0, *p*=1). As predicted repetition of well attested to frequency/familiarity effect across all participants (eg. Rayner et al., 1996). Looking at the intercepts to reveal the difference in RP reading time, shows a decrease of 16.03ms for a one scale unit increase for 'familiarity rating'. Looking at the 'Condition' intercepts reveals increases on the mean of the 'High' frequency condition, with a value of 329.99ms, the increase between; 'High' and 'Low' = 78.65ms; 'Low' to 'Zero'=83.98ms; 'High' to 'Zero' (Cumulative)=162.63ms.

As above for FP analyses, it was important to include one of the difficulty based variables (COMDIF and FLUDIF) as a second predictor, for the current analyses, they were virtually identical, although, FLUDIF showed a marginally better improvement. Therefore, the 'best fit' model again uses 'Familiarity rating' as the main predictor with the addition of FLUDIF and relevant values are seen in table (3).

3.23 Total-Time Analyses.

The same pattern seen for RP reading time is repeated for the TT output variable. Running the base model showed a TT mean of 431ms. The Familiarity Rating ($\chi^2(1)$= 3177.2, *p*=<0.001) and Condition ($\chi^2(2)$= 47.236, *p*=<0.001) are the only predictors that significantly improve the fit of the model, when ran as the first predictor independently. The remaining predictors, again, accounted for little of the variance seen, for all ($\chi^2(1)$= ≤0.1573, *p*=≥ 0.6916). This shows a third replication of the predicted frequency/familiarity effect across all participants (eg. Rayner et al., 1996). The intercept values which show the difference for a unit increase for 'familiarity rating' and 'Condition' can be seen in table 4. where they are compared to the previous values for FP and RP.

As above for FP and RP analyses, it was important to include one of the difficulty based variables (COMDIF and FLUDIF) as a second predictor, for Total Time, FLUDIF was the clear choice but still only showed a marginally better improvement. Therefore, the 'best fit' model again uses 'Familiarity rating' as the main predictor with the addition of FLUDIF and relevant values are seen in table 3.

Table 4-

A Table Showing the Intercept Estimates for Each Eye-Tracking variable for the given Predictors, values in (ms).

Predictor	FP	RP	TT
Familiarity Rating	-8	-16	-24
Frequency Conditions:			
(Intercept) 'High'	274	330	360
High'-'Low'	58	79	95
Low'-'Zero'	69	84	120
High'-'Zero'	127	163	215

4. General Discussion

The present study primarily aimed to explore the reading strategies of a group that exerted Communication Difficulty ('CD') versus one that showed a relative ease ('CE'), to answer the question of whether the 'CD' group shows disproportionate use of the GPC-route as described by the DRC model (Coltheart et al., 2001). To examine this, a silent reading eye-tracking paradigm, was used. The results of this experiment gave no support to this view.

4.1 Condition

It was predicted that there would be a frequency effect shown across the conditions of this experiment, as previously demonstrated (Rayner et al. 1996). This effect was seen at a significant level, with a relative increase in all reading time measures (FP, RP and TT) with a move from 'High' to 'Zero' condition, as seen in table 4 above. This is an expected effect and stems from the participants increased linguistic knowledge of the 'High' frequency condition target place names in comparison to the 'Low' frequency targets, leading to the shorter time course associated with easier lexical retrieval , that is seen in production studies (Jescheniak

& Levelt, 1994; Bien et al. 2006) and reading studies (Rayner et al., 1996). Therefore, this study shows a replication of the well attested frequency effects seen in these previous studies.

4.2 Familiarity

In much the same way as for 'Condition', noted above, a 'familiarity rating' effect is seen in the results of this experiment. 'Familiarity rating' proved to be the predictor that led to the 'best fit' of model, above 'Condition'. This is hardly surprising as the ratings of each target word are more fine-grained than the 'High', 'Low' and 'Zero' frequency condition groupings. Taking the high frequency group, there is variation in this condition that the familiarity ratings attest to, with some target words producing higher scores than others, a distinction which the 'familiarity rating' is shown to be sensitive too. Across the reading time measures, 'familiarity rating' was shown to exert at least an 8ms increase for a one unit increase in the familiarity scores. These results provide a replication of lexical familiarity exerting an effect on first-pass reading time (Francis & Kucera, 1982).

4.3 FLUDIF/ COMDIF

The main prediction of the present study was a difference in reading strategy between the 'CD' and 'CE' groups. The results here do not support any such difference including elevated reading times. Both of the difficulty predictors added very little to the base model of any reading time measure and could not even be seen to be trending towards a significant effect. There are a number of reasons why the pattern of results here could be seen:

The first is there could be no reading strategy difference between the 'CD' and 'CE' groups, which from the strength of the effect seen for the predictors COMDIF and FLUDIF is highly likely. In the context of reading strategy, the results show that for the current study there was no disproportionate use of the GPC route by the 'CD' group, which due to a the majority of the group being PNS who have shown normal fluency and reading abilities under testing is an understandable outcome. However, there were some genuinely disfluent PWS in the group, so why did they not show any of this differential reading strategy? A simple answer to this question is maybe they did show a disproportionate GPC-route bias but there was insufficient power for it to be measureable, especially coupled with the PNS data, which acted to normalise any differences shown in the 'CD' group data.

The important question is whether this result would have been seen with a larger and more defined range of scores on the COMDIF and FLUDIF scale. It the power of the study was doubled, a different pattern of results may emerge, as this would be expected to either lead to a more normalised set of data or reinforce the pattern of data resultant from this study. For the present study, the 'CD' and 'CE' groups were used as proxy groups for PWS ('CD' (thought of as pseudo stutterers for the purposes of this study)) and PNS ('CE' (relatively normally fluent)), if these groups were to be changed to exclusively PWS versus PNS, measured on actual language disfluency using the SSI-4 as a predictor, a different results pattern would be possible. There are a number of likely reasons for the failure of the present study to detect any significant effect of COMDIF or FLUDIF on the reading measures. The first is that even in the 'CD' group which represented the PWS participants and a number of controls, the majority of participants who were included in this group had no identifiable language disfluency on the SSI-4 scale, including one of the PWS, who exhibited no stuttering like disfluency in any of the disfluency tests or in any contact with the experimenters. This leads to question of the validity of the COMDIF and FLUDIF score. A second reason being that the score is a self-rating and not representative of actual measureable language disfluency. The nature of the OASES Section 3a, that was used to measure the participants for these scores is open to considerable variance in score between two similarly fluent PNS or two equally disfluent PWS; it simply relies on their own judgement.

The lack of support shown by the results for previous findings that PWS show elevated reading times (eg. Bosshardt & Nandyal, 1988) provide further evidence that the 'CD' group did not demonstrate the level of disfluency or communication difficulty needed for this effect to be seen. With these caveats in mind, we do not believe the current study to be representative of the actual pattern of results that would occur if the study was completed again using PWS participants against a matched PNS control group. Therefore the predictions made about reading strategy based on the DRC (Coltheart et al., 2001) are invalid due to the lack of relevant data available.

4.4 DRC predictions

In terms of the route usage predictions proposed on the basis of the DRC model, the current results suggest comparable route usage by both 'CD' and 'CE' groups, across all conditions.

4.5 Etiology of stuttering

Due to the lack of differences in reading strategy between the 'CD' and 'CE' groups seen for the current study, there can be no real insight extended to the issues of the etiology for stuttering. However, if the current study were to be ran again using the PWS/ PNS divide suggested above, which formed the original plan for the current study, and the results matched the predictions made here. There would be considerable support for a psycholinguistic theory of stuttering. The elevated PWS reading times across all conditions would support a phonological encoding based deficit as an element in the etiology of stuttering. If PWS were found to use the GPC-route disproportionately more, which would be realised as a significant increase in the magnitude of reading time effects seen only in one condition, most likely, the 'low' condition as there would be differential route usage then this could show another linguistic based deficit. Both of these would provide evidence for a non-speech motor plan cause for stuttering.

5. Conclusion

The current study did not show any divergent behaviour in reading strategy between the 'CD' and 'CE' groups. The only significant effects seen were a frequency and familiarity effect, where an increase in frequency or familiarity lead to a quicker reading time measure, this supports previous similar effects (Rayner et al.,1996.) Overall, as discussed above, this study was not representative of a true PWS versus PNS split, so renders the results invalid in drawing conclusions relating to the differences between these populations. A future replication of this study where there is a higher number of PWS and a matched PNS control group has a much higher likelihood of revealing significant reading strategy differences between groups, which would allow a valid discussion on the issue of PWS use of the GPC-route of the DRC (Coltheart, et al. 2001).

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7. Appendix

Section 1

List of Sentential Context- ??? Represent where target word would fit.

1. The old man from ??? had ten thousand stamps in his collection.
2. A teenage boy from ??? broke the regional hundred metre record.
3. Natalie went to ??? to recover from a broken heart.
4. The celebrity was arrested in ??? for punching a photographer in the face.
5. The village fair of ??? had a variety of events throughout the day.
6. The White Rose in ??? won an award for being the best local pub.
7. The primary school in ??? only has twenty pupils in each year.
8. Three teenage boys were arrested in ??? centre for being drunk and disorderly.
9. Tom insisted that ??? had the best kept park in the area.
10. In a local guide it was stated that ??? had won many awards.
11. The steam festival is always held in ??? during the summertime.
12. The farmers market in ??? is always held on a Saturday.
13. The folk festival held in ??? is staged in the main park.
14. The local football league of ??? was closely contested this year.
15. The census showed that??? has an ageing population compared to the previous one.
16. The tour group stayed at a small hotel in ??? for the night.
17. John said that ??? was his favourite place to camp in the summer.
18. Peter and his family wants to visit ??? to see the sights.
19. Jenny was told she was born in ??? at a small hospital.
20. The celebrity was photographed in ??? looking at houses for sale.
21. There were few teenagers in ??? as most had moved away.
22. The central point of ??? is St. Peters Church and graveyard.
23. The company proposed to build more houses in ??? by the river.
24. The roadworks in ??? caused a lot of disruption to the local area.
25. The couple enjoyed the helicopter flight over ??? looking at the festival.
26. The flooding of the local river in ??? caused widespread damage.
27. The lord mayor of ??? cut the ribbon to open the new supermarket.
28. The school trip to ??? proved to be a success with all pupils.
29. The proposed motorway through ??? was fiercely challenged by the locals.
30. The teacher was sad to be leaving ??? for her new school.
31. Serena decided that ??? was the best place to open a bakery.
32. The real ale festival was held in ??? on the Duke's Estate.
33. The lake in ??? was where all the local children spent their summer.
34. The hanging baskets at ??? railway station bloomed for the whole summer.
35. Charlie took his mum to ??? to shop for a birthday present.
36. The hikers stopped at an old pub in ??? for something to eat.
37. An old lady from ??? was the last surviving speaker of the local dialect.
38. Sarah could not wait to get back to ??? to meet her family.
39. The student went to ??? to study the inscription on the church.

40. The cricket team travelled to ??? for their cup semi-final.
41. The RSPB were pleased that a rare bird was nesting again in ??? sanctuary.
42. Scientists were concerned about a lack of newts in ??? pond.
43. Jamie decided overlooking ??? park was the best spot to eat ice cream.
44. The camp site in ??? had flooded after the torrential downpour.
45. The local politician for ??? had to resign after claims of bribery.
46. The electricity pylon in ??? got damaged after being struck by lightning.
47. The town hall in ??? was damaged after a storm blew off roof tiles.
48. There was no alcohol allowed in ??? square during the boat festival.
49. The troop of Morris dancers from ??? won a national competition.
50. The local council in ??? was thinking of rebuilding the golf course.
51. The candle factory in ??? burned down after an accidental fire.
52. The Antiques Road show's visit to ??? unearthed a rare Turner painting.
53. A local man in ??? found a Roman coin horde while metal detecting.
54. A street party was thrown in ??? to celebrate the Queen's jubilee.
55. There was uproar in ??? when the local post office closure was announced.
56. The college in ??? put in planning permission for a new sports hall.
57. A pet snake from ??? escaped causing panic in the local community.
58. A teenage girl who lived in ??? reached the final of X-factor.
59. Madeleine was excited that ??? was finally getting a bigger supermarket.
60. Tony decided that the job in ??? was too good to turn down.

Section 2.

Table 5-

A list of Target Place Names by Frequency.

Number	High Frequency>200	Freq.	Low Frequency>50	Freq.	Zero Frequency	Freq.
1	Anfield	204	Anerley	45	Anstead	0
2	Chelmsford	469	Chelmer	6	Chelmstead	0
3	Cheshire	1067	Chesney	47	Cheston	0
4	Chester	1082	Chesser	26	Chesper	0
5	Chiswick	277	Chiswell	8	Chisward	0
6	Cleveland	1697	Cleveleys	31	Cleveway	0
7	Darwin	1122	Darzin	13	Darbin	0
8	Doncaster	427	Donegan	10	Donward	0
9	Dover	470	Dovey	18	Dovart	0
10	Durham	2432	Durban	13	Durgan	0
11	Elton	345	Elvin	34	Elten	0
12	Exeter	767	Exmouth	33	Exston	0
13	Franklin	461	Frankel	12	Frankton	0
14	Geneva	1037	Gennaro	9	Gennert	0
15	Hague	507	Hagley	31	Hagton	0
16	Halifax	696	Halkyn	7	Halkton	0
17	Hamburg	386	Hambury	15	Hambett	0
18	Hammersmith	347	Hammerton	11	Hammerdon	0
19	Hampstead	374	Hamstone	7	Hamstard	0
20	Hastings	774	Haston	9	Hastbury	0
21	Joyce	1301	Joynes	7	Joynet	0
22	Kensington	674	Kensal	25	Kenstun	0

23	Kingston	394	Kingswear	6	Kingstarn	0
24	Lambeth	297	Lamborne	12	Lambston	0
25	Lancaster	1159	Lanchester	53	Lancminster	0
26	Langley	254	Langney	15	Langstey	0
27	Lincoln	924	Lindford	7	Linston	0
28	Lisbon	358	Lisson	22	Listron	0
29	Luton	445	Lutton	16	Luston	0
30	Melbourne	369	Melbury	10	Melburton	0
31	Middleton	342	Middlewich	19	Middlestun	0
32	Monaco	221	Monckton	16	Monaston	0
33	Nairobi	252	Naisbitt	11	Naiston	0
34	Newbury	343	Newby	46	Newtry	0
35	Newport	411	Newsom	11	Newston	0
36	Norfolk	1412	Norham	17	Nortbury	0
37	Normandy	352	Normanton	22	Normanstun	0
38	Northampton	984	Northanger	15	Northaves	0
39	Oldham	408	Olding	7	Oldston	0
40	Ontario	336	Onuca	6	Ontaston	0
41	Orlando	218	Orleton	8	Orlaston	0
42	Oswald	295	Oswick	7	Oswart	0
43	Otley	243	Ottey	8	Otrey	0
44	Paddington	343	Paderborn	12	Paderton	0
45	Pembroke	249	Pembury	13	Pemston	0
46	Picadilly	251	Pickerstaff	25	Pickerston	0
47	Skelton	265	Skeldale	6	Skeldon	0
48	Rochester	511	Rochford	36	Rochston	0
49	Torquay	288	Torbay	10	Tortry	0
50	Walton	474	Walvin	8	Walston	0
51	Walsall	312	Walsham	20	Walstry	0
52	Ramsey	695	Ramsbury	9	Ramstead	0
53	Reading	908	Reddan	9	Readston	0
54	Redcar	390	Redburn	29	Redstead	0
55	Richmond	978	Richfield	10	Richerston	0
56	Scarborough	624	Scarsdale	15	Scarston	0
57	Seattlle	204	Seaview	33	Seaston	0
58	Sedgefield	241	Sedgeley	7	Sedgestead	0
59	Selby	412	Selden	7	Selsten	0
60	Taunton	296	Tawell	32	Tawstead	0
	Mean Freq.	572.9	Mean Freq.	17.2	Mean Freq.	0