Empowering Expression for Users with Aphasia through Constrained Creativity

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ABSTRACT

Creative activities allow people to express themselves in rich, nuanced ways. However, being creative does not always come easily. For example, people with speech and language impairments, such as aphasia, face challenges in creative activities that involve language. In this paper, we explore the concept of constrained creativity as a way of addressing this challenge and enabling creative writing. We report an app, *MakeWrite*, that supports the constrained creation of digital texts through automated redaction. The app was co-designed with and for people with aphasia and was subsequently explored in a workshop with a group of people with aphasia. Participants were not only successful in crafting novel language, but, importantly, self-reported that the app was crucial in enabling them to do so. We reflect on the potential of technology-supported constrained creativity as a means of empowering expression amongst users with diverse needs.

KEYWORDS

Constrained creativity; accessibility; content creation; aphasia; creative writing; poetry; creativity; speech impairments.

1 INTRODUCTION

"*The more constraints one imposes, the more one frees one's self of the chains which shackle the spirit.*" — Igor Stravinsky [44]

Creativity refers to the act of bringing something new into existence. It applies across myriad domains, beginning with the very process of thinking and continues through to the production of artistic artefacts such as musical compositions, works of art and literature. Being creative is often a rewarding endeavour and has been shown to afford significant benefits, for example, to mental well being [10] and self esteem [19]. It is, however, challenging to be creative and many individuals do not consider themselves 'creative people'. To this end, various techniques exist to provoke and support creative acts [46]. One such technique is *constrained creativity* [43] or "*thinking inside the box*". Constraining the space within which a creative act is enacted affords the exploration of boundaries and is an effective tool for initiating novel artistic endeavour. Composer Stravinsky [44] (pg. 60) describes his challenges with creativity in musical composition, stating that it is the freedom of numerous choices that blocks his musical creativity; conversely, limiting the possibilities enables ideation and frees the creative spirit. Therefore, a composer might limit themselves to using a specific set of notes (as in serialism), or a painter might limit themselves to a single brush technique (as in impressionism) to generate an initial 'spark' of an idea or to complete an entire work. Further, constraints might guide and support a user – a simple example being drawing with a stencil.

In this work, we explore the idea of applying constraints to the creation of written language. The various forms of written language, such as poetry, lyrics or even limericks are a means by which we can convey sentiment and are a conduit through which we may shape ideas. However, people with speech and language impairments, such as aphasia, struggle to engage with these rich forms of expression. While much of the literature on technology for people with diverse needs focuses on rehabilitation, we focus on enabling creativity. Specifically, we explore how constrained creativity can be employed to broaden access to digital creativity for people living with aphasia. This paper contributes the following:

- A new approach for digital technology to facilitate constrained creativity;
- *MakeWrite*, a novel tool co-designed with people with aphasia which utilises intentional, automated constraints on language to foster creativity;
- Findings from using *MakeWrite* with a diverse group of people with aphasia.

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2 BACKGROUND

Constrained Creativity

Constrained creativity refers to the process of generating something new from a restricted set of resources. These constraints can be external or self-imposed. Whilst constraints elsewhere might have negative connotations, constraining oneself intentionally in a creative process is a technique widely-used to inspire new creative possibilities [43]. In impressionist painting, for example, an artist often uses a single technique – e.g. thin, small brush strokes to build up a larger scene. As noted by Biskjaer and Onarheim [4] "*certain constraints can also be helpful and even crucial in creativity*". Biskjaer and Onarheim [4] study two domains (art and engineering design) reporting that, in addition to constraints such as budget and time, teams also leverage self-imposed constraints to promote creativity. Stokes [43] notes how, while the materials and process of the act of creation are obvious constraints, those assigned by the actor in the task can also play an important role in creativity. Similarly, Lazar et al. [25] discuss materiality in art therapy, arguing that different materials have different expressive possibilities. They propose (via Moon [33]) that fluid materials support affective and sensory states, whereas rigid materials like pens might afford expressions of structure and boundaries.

Constraints might also serve to support a user more explicitly: Dahl and Moreau [12] argue that consumers' choices to engage with pre-constrained crafts such as 'paint-by-number', speciality crafts and model trains, are motivated by feelings of competence, autonomy and a desire to learn. It is important to note here that even though most of the 'work' is done by an outside party – i.e. those who designed and built the kit – enjoyment is still gained from such constrained creative activities. The space we address in the work reported in this paper is intentionally constrained. Crucially, however, we seek to enable people to create original artefacts in contrast to the 'paint-by-number' approach where the outcome is pre-defined.

Creativity Support Tools which Utilize Constraints

Digital creativity support tools enable people to articulate artistic intent in digital form. The extent to which the software assists the creative process varies between tools, but these tools commonly require an extensive learning process in order to produce a sophisticated output. Shneiderman [42] however, proposes that, when considering creative support tools, one should "*Design with low thresholds, high ceilings, and wide walls*". That is, systems should be designed for non-experts, while providing the functionality that experts need. To this end, much research has considered how we may broaden access to the digital creative process through tools that undertake much of the creative cost with minimal sacrifice of expression on the user's behalf. To create music, for example, one must explicitly or implicitly grasp a complex set of heuristics (chord sequences, scales and rhythm). Many researchers have considered how these rules may be modelled computationally to broaden access to musical composition for amateurs. Bengler and Bryan-Kinns [3], for example, describe *Polymetros* – a system enabling non-musicians to be creative by controlling a number of parameters within a constrained structure; meaning that a number of people playing together will always sound complementary. Coughlan and Johnson [11] identify how constraints may serve to supplement musical creativity in an end-user development tool, e.g. by blocking 'unused' notes to lower the cognitive effort to engage with an instrument, similar to the concept employed by the popular app Garageband. Similarly, Benedetti et al. [2] describe a drawing tool that allows users to create their own versions of pictures. The tool assists the painting process by providing contours that automatically paint 'within' the lines of existing pictures, allowing users to add their own creative style.

Generative and Supported Written Creativity

A number of digital tools generate creative writing. These generally produce poems and similar texts from a combination of user input, such as the choice of words, and an algorithm which dictates the output poem [18, 35]. Other tools take an interactive approach, forming the poem from live input. For example, Pereira and Maciel [37] investigate the effects of users interacting with generative literature, Mendelowitz [31] explores an algorithmic approach to a user generating poetry from sketch-based input and Marshall [30] uses the input of running intensity to alter the effects in a read poem. Such poem generating tools sit on a continuum where there is a tension between the work done by the user and the work done by the machine. Tools such as Zhang's neural-net-based poem generator use previously created pieces to generate new poems [49]. This affords the user no agency in the creation. Other poetry generators (e.g, online haiku generators) offer a degree of control over basic elements of the poem within a rigid structure. Regardless of where each tool sits on this continuum, no tools currently exist which generate and support creative writing in a form accessible for a person with a speech and language impairment such as aphasia.

Aphasia and Content Creation

We now consider creativity within the context of aphasia. Aphasia is an impairment of language caused by damage to the brain (most often through stroke). It can affect all aspects of language: reading, writing, speech and comprehension despite intellect being largely unaffected [1]. Aphasia impacts

upon every individual differently. For example, some people may find writing more difficult than speaking, whereas others might have specific difficulties in understanding spoken language. The condition affects around one third of stroke survivors with estimates that there are around 2 million people living with aphasia in the USA alone [1]. However, despite its prevalence, less than 10% of the wider population know what aphasia is [9] – illustrating its status as a largely invisible condition. An ageing population and increasing odds of surviving a stroke imply that the number of people affected by aphasia will continue to increase – and a growing number of individuals will be faced with diminished opportunities to convey their intellect and creative potential due to their language barriers.

Multiple aspects of the creative process may prove challenging to people with aphasia. Many creative activities, such as poetry for example, necessitate extensive language processing. Chris Ireland, a poet with aphasia, gets around this by engaging a 'poetry editor' (a speech and language therapist friend without aphasia) to help edit and refine her work [23]. Ireland's work, and related discussions [24], report the beneficial experience for her of creative writing (via Bolton et al. [5]). She describes her work as a celebration of the language of aphasia (complete with 'erroneous' spelling and grammar) and a liberating tool in which she is empowered through creativity. Others with aphasia may not enjoy similar access to a 'poetry editor' friend and might look to technology for support. Research indicates, however, that the language demands implicit in many aspects of technology-use present barriers for people with aphasia [8, 20, 32, 40]. The testing of social media tools with people with aphasia [39], for example, has shown that they can present a number of barriers [21]. This means that many creativity support tools, such as those described previously, are not available. Inevitably, this leads to challenges for people with aphasia hoping to engage with the process of digital creativity.

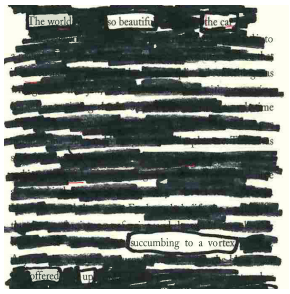
Work has been undertaken to create technologies accessible to people with aphasia. These technologies have mainly focused on either the *rehabilitation* of communication, e.g. to retrain lost vocabulary [36], or the use of language in a very functional capacity. For example, Waller et al. [47] investigated how we might assist people with aphasia to make conversation. One commonly reported method employs images to support communication [7, 28, 29]. Other work seeks to support more practical activities such as cooking [45]. Accessible digital technologies have also enabled rehabilitative therapy for improving gestures [41] and spoken language [16, 26]. Contrasting work has sought to classify aphasic language input computationally [15]. Very little work, however, has focused on enabling *creative* digital output. Whilst rehabilitation is unquestionably important, we aim to provide a contrast to existing functional technologies by considering how we can engage people with aphasia in a digital process of creative writing. We do this through *MakeWrite*, a novel tool that utilises constrained creativity to enable people with aphasia to play with and shape language, facilitating meaningful and enjoyable creative writing.

3 EXPLORING CONSTRAINED CREATIVITY

Erasure Poetry

The work reported here was inspired by the potential of *erasure poetry* to allow people to scaffold their creativity by building on the work of others. In erasure poetry (also known as blackout poetry), one removes parts from a source text, typically by redacting with a pen, to leave behind a new poem (Figure 1). This creates poems, or small pieces of creative writing, related or unrelated to the original text.

We explored erasure poetry in one of our regular research team creativity sessions. Although none of us would regard ourselves as creatives (and certainly not as poets), we all created erasure poems with relatively little effort and a lot of pride in the outcome. Filled with a sense of achievement, we then encouraged others to participate by placing pages from a book around our research lab, and received a number of additional poems in response. See Figure 1.



The world, so beautiful

the car, succumbing to a vortex

offered up

Figure 1: Excerpt from an erasure poem written on the day a billionaire launched a used car into space, redacted from '*The Brief Wondrous Life of Oscar Wao*' by Junot Díaz [13].

Subsequent reflection suggested to us that applying constraints to the creation of text could be a powerful enabler for people with speech and language impairments – providing a constrained vocabulary space within which texts could be created and overcoming the challenge of starting from a blank slate. We also identified, however, that the erasure poetry activity, as we had undertaken it, was likely to be linguistically challenging for those with a language impairment – due to the number and density of words presented on a typical page – but that there may be an opportunity for digital tools to assist this process. We undertook a co-design activity to explore this opportunity, leading to the development of a prototype app (*MakeWite)*. This work was undertaken within the ethics framework of City, University of London.

Co-Design

Following our initial exploration of erasure poetry, we worked with four co-designers with aphasia to probe the feasibility of using technology-assisted erasure poetry as a form of constrained creativity. The co-designers were employed as consultants. All had mild/moderate language difficulties due to aphasia as a consequence of stroke, were at least six months post-stroke and had spoken English fluently prior to their stroke. They were aged between 44 and 68 years old (average = 58). We undertook three co-design sessions for this purpose; these were audio and video recorded for later reference. The co-designers generated ideas in the first session and worked with us in subsequent sessions to refine prototypes as the design progressed. Our goal was to ensure that any technology would be both accessible to people with aphasia and would empower them to create creative content.

Ideation with Initial Prototypes

We worked with the co-designers to explore the idea of automated erasure as a means of digitally assisting constrained creativity – first through a paper-based simulation ("paper grids") and then through a simple prototype app which mirrored the process in a digital form. We discussed the efficacy of these methods during and after the session supported by visual rating scales. These scales provide visual cues in addition to numbers (e.g. a 'thumbs up' or 'thumbs down' at the ends of a Likert Scale, similar to [17]) to support people to express their thoughts and quantify their sentiments.

Paper Grids. We first simulated the concept of 'automated' redaction using paper grids. Co-designers were given a source text laid out in a grid pattern on A3 paper and overlays with holes cut out. The overlays 'redacted' the majority of words from the source. Co-designers were able to redact varying amounts of text by moving the overlays and by selecting alternative overlays (Figure 2). The goal was to explore whether reducing the cognitive burden of redaction would enable people with aphasia to borrow words from a source text to create their own expressive outputs.

After practice applying overlays to the paper grids, all of the co-designers with aphasia were able to create written texts with which they were satisfied. Indeed, this 'automated' redaction of a large body of text made the selection of words more achievable. However, a challenge with the word sets elicited by the overlays was that by spotlighting just one word at a time, elements of texts which naturally consist of two or three word phrases were lost – sometimes leaving the emergent subset of words fragmented and lacking in potential for composing new phrases.

Over the course of the activity, it naturally evolved into a collaborative exercise. We noted there was increasing engagement with the poetry activity and that people began to 'riff'

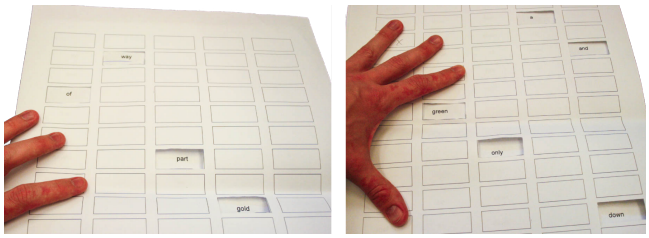


Figure 2: Word blocking exercise analogous to automatically redacting texts (self-imposed constraints). Left, a paper grid is placed over a spaced grid of words. Right, this grid is turned upside-down and a different set of words emerge.

ideas off each other to create something new with language. For example, one co-designer noted: "*Maybe if each person does a chunk and then get everyone together for the poem*". By taking it in turns to generate lines using the paper grids, the group produced a series of creative texts, for example, a short Haiku-sounding poem entitled '*The Hemlock Grief*':

The Hemlock Grief
The change subsides
Her tree only sank
It's almost dark

Initial Automated Redaction Prototype. We next explored automated redaction through a software prototype built in the *Processing* programming language. This prototype used the same concept of blocking out sections from a grid of words, but did so with blocking grids which blocked out words with an user-defined probability (between 10% and 90% in increments of 10). This prototype was demonstrated by one of the researchers and projected onto a screen in the lab during the session, with direction from the co-designers. The redaction was repeated until a preferred set of words was identified. The selected words were then written out and rearranged by the group to create a new text.

The iterative approach of rendering multiple redactions of the text supported by this prorotpe was received positively. This approach made each set of words less precious, meaning that multiple iterations could be viewed quickly until a preferred set of words was available. This made for an easier process of being creative with language. One co-designer stated that the blocking of the words enabled them to create a text that they were happy with, likening it to a crossword and describing it as a "*surprisingly rewarding experience*".

From these initial exploratory activities, we drew several conclusions for the development of an app that would utilise constrained creativity to support people in creative writing: that allowing for the retention of more grammatical structure from the source text might support writing (e.g. by supporting selection of small chunks of text instead of isolated words); that user collaboration proved effective when

possible but the app should encompass a fair power dynamic; and that facilitating multiple iterations of redactions of the source text allowed users to generate creative language.

Co-Design of *MakeWrite*

We next conducted two co-design sessions to iteratively design an app that uses automated redaction to enable people to play and experiment with words and produce creative output. The goals were to build on the findings from the ideation session and to deliver an aphasia-friendly, accessible app. We decided that the app should have three stages: one to allow the users to choose the source text they want to redact ('Choose'); one where they apply the computer-aided redaction ('Erase'); and a final stage to arrange the text ('Arrange'). The co-design process employed techniques such as SWIM (Someone Who is not Me) [48] via co-created personas [6, 34] and visual rating scales (as above) to facilitate idea generation and feedback for these three stages.

Choosing the Source Text. Although a source text might be drawn from anywhere (e.g. a website, book or poem), for the sake of the simplicity, we chose to limit the prototype app to six short creative texts (poems and short stories). We considered how the source texts might be presented for users to make a choice – exploring a number of means to identify each source text, including plain word labels and word-clouds generated from the texts. The co-designers advised that a picture with a text label would support them to understand the main theme of each text: "*You can put some picture in. That would help. Picture will make many words*".

Automatic Redaction of the Selected Source Text. We wanted to give users control over how much text is redacted. Based on feedback in the co-design sessions regarding the number of words that would be appropriate, the amount of redaction was changed to have an upper limit of 10% retention of the source text (i.e. at least 90% redaction). Furthermore, informed by the findings of the first co-design session, we wanted to retain some elements of the source text structure as co-designers found it challenging to link isolated words. Therefore, we explored use of a 'text grouping' function to allow users to specify that some of the words should be in chunks of either two or three adjacent words. This was received positively. Finally, after exploring an initial visual design, all UI elements were made larger and arranged to afford easier interaction for people with aphasia (i.e. taking into account non-dominant hand use and the consequent need for interaction targets which require less accuracy).

Arranging the Text. For the final part of the process, we wanted to offer an interface that enables users to organise the selected word subset as they wish. Here we were inspired by fridge poetry (a form of *Vocabularyclept* [27]), a form of constrained creativity where people arrange a finite set of words to create varying outputs. After exploring an initial design with the co-designers, it became clear that to 'clean up' any unwanted words, this phase should provide a simple way to delete selected words. Co-designers also indicated that there should be an option to add words. To support this, we created a button to allow users to elicit one randomly-selected additional word at a time from the pool of previously rejected words in the source text. We took the decision to avoid the option of word entry via keyboard input – which might exclude those users with typing difficulties – to ensure that all users wishing to add new words could do so on an equal footing. The visual design of the *Arrange* screen (e.g. the size of the words and their padding) and the interaction (multiple fingers) were designed with input from the co-designers.

Capturing the Content. Finally, we discussed with the co-designers how they and other people might want to share the created texts. All co-designers expressed a desire to share the texts with close individuals such as family and friends, but there were some reservations about wider sharing to social media. Hence, rather than an automatic 'publish to social media' option, we opted to implement the option for the user to save an image of the text they had created, and this could later be shared however they might choose.

4 OVERVIEW OF MakeWrite

We now describe the resultant co-designed app. *MakeWrite* is a prototype app that enables users to take a source text, automatically redact it according to selected parameters, and then arrange the redacted text in such a way as to create a new form of written expression. *MakeWrite* has three consecutive stages, each dedicated to one specific task: *Choose*, *Erase* and *Arrange* (Figure 3).

The 'Choose' Stage

The first screen of *MakeWrite* invites the user to choose a source text from a selection of six short creative texts.

The 'Erase' Stage

Once text is loaded from the original source, the user may begin redacting words to find a group that they like. Automatic redaction is initiated by pressing the yellow 'Refresh' button (Figure 4). The percentage of redaction can be altered through use of a slider (set, by default, so that only 5% of text will remain after redaction). Users can choose to retain between 0% and 10% of the source text. The word grouping feature enables chunks of either 1, 2 or 3 words at a time to be generated by pressing the appropriate button. Here, if a word appears, in accordance with the percentage redaction feature, then '*n*' words will also be visible after that word. The

Figure 3: *MakeWrite*: a) the 'Choose Stage', b) the 'Erase Stage', c) the 'Arrange Stage'.

user is free to manipulate percentage redaction and grouping constraints until they arrive at a group of words they would like to use as a starting point for their creative text.

The 'Arrange' Stage

The elicited words are then presented on a grey canvas area within the 'Arrange' screen. Users can drag and rearrange the words with multiple fingers to form a new text composition. A word can be deleted by moving it to the 'Drag here to delete' region. Users may also add words from the previously 'rejected' set of words from the 'choose' stage. Pressing the 'New word' button will spawn a randomly-selected word into the grey region below the button.

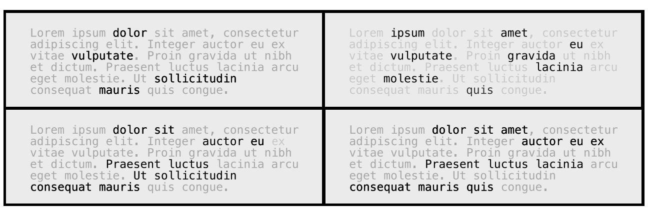


Figure 4: Variations of redaction: top left and top right show the variation in word retention (10% and 20% respectively). Bottom left and bottom right show the variation in the word grouping (2 words and 3 words per group respectively).

5 'POETRY' CREATION WORKSHOP

To explore use of *MakeWrite* within a real-world setting, we conducted a creative writing workshop at a drop-in session for people with aphasia[1]. The drop-in session is a weekly event where people with aphasia in the local community can access communication support from speech and language therapists (SLTs), speech and language therapy students (SSLTs) and peers with aphasia. Those attending were made aware in advance that the session would include a poetry activity with researchers and were given the option to opt-out of the activity in favour of their regular session activities.

The aim of this workshop was to understand the effectiveness of *MakeWrite* for enabling people with aphasia to create new texts (referred to as 'poems' as a shorthand within the context of the workshop). Owing to the nature of the drop-in session, we could not control for aphasia severity. Given the app had not been created with explicit input from users with severe aphasia we expected a variety of outcomes when putting it to the test within this broader context. The workshop was run by a human computer interaction (HCI) researcher, three professional SLTs and one SSLT. The SSLT and two of the SLTs had not been part of the co-design team.

Procedure

At the beginning of the workshop, participants were supported to access the information and consent procedure by the SLTs and SSLT. This was followed by completion of an aphasia accessible interview to gather demographic information (reported in Table 1). To capture details of aphasia, participants were asked to self-report their perceived difficulties with reading, writing, speaking and listening, by reflecting on their ability to complete a series of tasks which ranged from more to less complex. For example, to understand a person's writing ability, we asked participants which (if any) of the following they felt able to produce: long texts (like a story); a letter or email to a friend; simple sentences; some single words; their name. We also asked them to report any physical impairments. Data capture was supported by use of aphasia-accessible forms and varying degrees of facilitation from the (S)SLTs.

MakeWrite was then demonstrated with the iPad screen projected onto a large display. This was undertaken by one of the SLTs who has extensive experience in using digital technologies alongside people with aphasia. Participants then divided into five self-selecting groups to use *MakeWrite* on one of the five iPads provided in the workshop. They were

[1]We initially referred to the session as a poetry workshop. Over time, however, we have come to consider the term 'creative writing' a more fitting descriptor of the activity.

asked to work together to create poems. Where necessary, the use of the app was supported by an SLT or SSLT facilitator. When participants had finished creating their poems, they were supported to complete a feedback questionnaire which included rating their agreement/disagreement to the key statement *"I wrote a poem with the app that I could not have written without it"* (see Table 3).

We adopted this workshop-based approach to investigate usage of *MakeWrite* because SLTs on the research team expressed the view that it was not reasonable to ask participants to engage in unsupported creative writing (indeed, this challenge was the original motivation for the app). For this reason, a formal comparative evaluation between the creative writing outcomes achievable with or without the app was rejected in favour of participants' self-evaluation of their *MakeWrite* 'poems' against their ability to write poetry without the app.

Data Collection and Analysis. Each iPad recorded all interactions both as video and audio and also as event-based log data. As mentioned above, after the usage phase, participants reported their experience of *MakeWrite* through a questionnaire with visual rating scales (facilitated by SLT and SSLTs outside of the app design team). Additional video and audio recordings of the workshop were used to triangulate findings from the primary data sources. Log and interaction data was summarised using descriptive statistics. Qualitative and quantitative data from user evaluation forms were collated, summarised and reviewed for emerging themes.

Participants

Fifteen people attended the drop-in session; all were offered the opportunity to take part in the creative writing workshop. Two people opted not to do so and engaged in other tasks. We report data from the remaining 13 participants, identified as A – M (Table 1). There were 4 female and 9 male participants with an average age of 60.7 years (SD = 10.7; min = 48; max = 85). Participants reported varying degrees of language difficulties as a result of their aphasia – reflecting the typical diversity of the broader user group with aphasia. Five participants reported some degree of difficulty with reading, nine with writing, six with speaking and four with understanding speech. One participant (p.I) reported no identified difficulties from the presented list of options – indicating that she experienced more subtle but nonetheless impactful effects upon her language. Another participant (p.M), in contrast, reported difficulties across all four domains. All but four participants reported additional physical impairments. These were mostly one-sided weakness or paralysis as a result of a stroke (hemiplegia/hemiparesis), meaning that several participants had mobility issues and/or limited use of their dominant right hand. Group configurations for the self-selecting groups are identified in Table 2.

Results: Erase Stage

Word Redaction and Grouping Parameters. When interacting with the 'Erase' part of the app, participants used the word redaction and/or grouping features to set parameters on 78.89% of occasions where words were taken to the 'Arrange' stage. Interaction with the grouping feature buttons was more common (68.97%) than with the word redaction slider (58.62%). Following use of the grouping feature, the average word group size increased to an average of 2.35. The average amount of text remaining following use of the redaction slider was 6.88%. Most often, participants increased the value from its default 5% value (70.59% of the time).

Results: Arrange Stage

Movement of Words. As a proxy for engagement with the text arrangement activity at this stage, we consider the movement of words. We logged each time a user moved their finger. Some groups moved the words considerably more frequently than others,e.g., Group 2 only touched 72 words, whereas Group 3 touched 149 words.

Figure 5: Kinetic video heat-map of the arrange stage, with interface superimposed for reference: Group 2 (left) mostly used the words chosen from the 'Erase' stage. *Group 3* (right) regularly spawned and then moved words to the delete area.

Word Spawning and Deletion. Across the 5 groups, 428 words were deleted and 440 words were spawned – a net of 12 extra words (428 - 440). This was a result of very different usage behaviours between the groups (with net deletions of words ranging from -79 (Group 1) to 165 (Group 5). Some groups deleted considerably more words than others. Analysis of video heat-maps suggested two main variations in user behaviour at this stage (Figure 5). This variance is also reflected in the word spawn and deletion data. This contrasts to *Group 1* and *Group 3* who used the words generated in the 'Erase' stage more often.

Results: Outputs of Process

Output Texts and Log Data. The logs show that the average usage time of *MakeWrite* during the workshop was 45:45.30

ID	M/F	Age	Difficulties Reading	Difficulties Writing	Difficulties Speaking	Difficulties Understanding	Writes Now	Wrote Before
A	m	67	-	Long texts	Using more than a few words	-	No	Yes
B	m	56	-	-	Speaking for a long time	-	NA	NA
C	m	73	Books	Long texts and letters	-	-	No	No
D	m	59	-	Long texts	Speaking for a long time	-	No	No
E	f	59	Books and magazines	Long texts	Speaking for a long time	-	Yes	Yes
F	m	85	-	Long texts	-	-	Yes	Yes
G	m	NA	NA	NA	NA	NA	NA	NA
H	m	61	Books	Long texts	Speaking for a long or short time	-	No	Yes
I	f	NA	-	-	-	-	NA	NA
J	f	56	-	-	-	Some phone conversations	Yes	No
K	m	53	-	Long texts	-	Some phone conversations	No	No
L	m	48	Books	Long text and letters	-	Phone conversations	No	No
M	f	51	Books, magazines, short instructions, menus	Long texts, letters, simple sentences	Speaking for a long or short time	Radio, TV, phone and in-person conversations	Yes	Yes

Table 1: Self-reported participant details: m = male; f = female; NA = not answered; - = no difficulties identified amongst list of provided options. 'Writes now/before' referring to participant's poetry writing pre/post stroke.

(mm:ss.ms) per group. Over the course of this time, a total of 28 texts were created. Figure 6 presents four of the texts, giving an indication of the variation in length and content.

Output Texts created. Table 2 provides a numerical summary of texts produced within the 'Arrange' stage. The average number of texts produced per group was 5.6. The average number of words was 11.3. Words were spread over a minimum of 1 and a maximum of 7 lines. Groups spent an average of 7:08.90 minutes creating each text.

Group (Participants)	Num.	Words	Lines	Time
Group 1 (B, L, M)	7	5.9	2.3	04:22.1
Group 2 (C, D, E)	4	11.5	2.5	06:34.2
Group 3 (F, G, H, I)	7	10	2.1	10:40.6
Group 4 (A)	4	4.5	1.3	04:53.0
Group 5 (I, J, K)	6	25	6.2	09:14.7
Averages	**5.6**	**11.3**	**2.9**	**07:08.9**

Table 2: Descriptive statistics of texts created by groups as a result of the 'Arrange' stage

Questionnaire Data. The quantitative Likert data from the questionnaire statements (S1 - S8) are shown in Table 3. At least half of all respondents either agreed or strongly agreed with each statement (56 out of a total of 99 responses), indicating a generally positive response towards *MakeWrite*; 20 (of 99) responses were neutral and 23 were in disagreement or strong disagreement. S1, S2 and S3 elicited the highest levels of overall agreement and S4, S5 and S6 elicited the greatest disagreement. Eight of 13 participants agreed that they had made something new with the app (S1). However, two participants either disagreed (p.H) or strongly disagreed (p.C) with this. Participant H, in his written comments, expressed that there were too many words for him to work with "*3 words enough!*". Eight of 13 and 9 of 13 participants respectively agreed that *MakeWrite* enabled them to write a 'poem' that they could not have written without it and that they had enjoyed using the app. One participant noted that he liked to reduce the complexity – i.e. cut down the number of words – to work something into a a new form "*I enjoyed making choice to make something simple*" (p.L)

Four of 12 participants disagreed with statement S4: "*I felt the poem I created was my own work*". Those in disagreement generally cited one of two reasons: either that the words came from the original text and therefore it was not theirs – "*from the book!*" (p.A) or, that by working in a group, they felt that the other members of the team did most of the work, for example p.C – "*team helped*". Some participants expressed a desire to add their own words, for example p.B: "*No not my own work I would like to type my own words*". Five of 12 participants disagreed with statement S5: "*I felt proud of my poem*". Some participants, who felt that the process of redacting and arranging the text was something that *they* did, were very enthusiastic about the process – "*It was me*" (p.B). However others, again, felt that as the words were sourced from a pre-existing text, the work was not as much theirs. Finally, 4 of 12 disagreed with statement S6: "*My poem allowed me to express a thought or feeling*". Participant B wrote: "*No it wasnt the words i would have use*".

Additional Comments. Several participants noted some improvements that could make the app more suitable for them, for example, by changing the content available during the 'Choose' stage: "*I want more choices at the beginning I would like to be able to choose the topics at the beginning.*

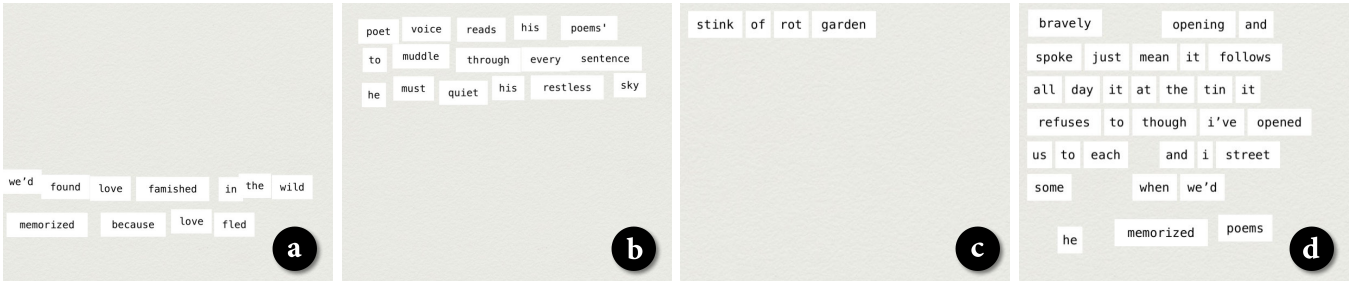


Figure 6: Four differing examples of texts from the groups: a) from Group 3; b) Group 2; c) Group 4; d) Group 5. Texts a) and b) take an almost Haiku-type form. c) takes a more minimalist approach, wherein p.A mostly used a few words to create sentences he found amusing, and d) was typical of Group 5, who often used a (comparably) large number of words in their creative texts.

Statement(S)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1) I made something new with the app	1	1	3	3	5
2) I wrote a poem with the app that I could not have written without it	1	0	4	2	6
3) I enjoyed using the app	1	2	1	4	5
4) I felt that the poem I created was my own work	3	1	1	3	4
5) I felt proud of my poem	2	3	0	3	4
6) My poem allowed me to express a thought or feeling	4	0	3	0	5
7) The app was easy to use	2	1	3	3	3
8) I would like to use the app again	1	0	5	1	5

Table 3: Likert scale results from the workshop. S1-S3 elicited 13 participant responses; S4-S8 elicited 12.

For example, football" (p.K). Additionally, participants noted that it would be useful if the app was able to read out the more challenging words: "*It would help to read out difficult words*"(p.M); "*It should talk*" (p.B). Finally, participants with more severe aphasia indicated that the complexity of the original texts in the app was too great and that, ideally, it should be simpler or that they would require more time: "*written words are difficult. 1-2 or 3 words at once is the most that I can imagine*" – "*confusing. Too many words. Abstract words*" (p.H).

Discussion of Results

The diversity of the participant group in the workshop can be considered representative of the user population of people with aphasia. However, the consequent heterogeneity of the results makes it challenging to identify a group consensus and hence to infer specific implications for individual aphasia profiles. The results have, however, provided us with valuable insights into designing for this diverse population and we are able to identify important overall themes.

Significantly, the results indicate that *MakeWrite* enabled a variety of users with aphasia to create new text compositions. Several outcomes support this: from the fact that each group was able to produce a number of new texts during the workshop, through to the number of participants who agreed with statement S2 on the questionnaire ("*I wrote a poem with the app that I could not have written without it*"). At a group level, the variation in the number of words spawned and deleted is indicative of the way that the different groups worked to create the texts. The behaviours noted from the logs (Figure 5) suggest that some groups utilised the constrained redaction technique fully, whereas others used it as the initial 'spark' to elicit a basic text. To make the text their own, they then opted for a more 'brute force' approach by spawning and rejecting words.

There is evidence that most participants enjoyed using the app (S3, Table 3). Some, however, experienced difficulty. Participants C and H expressed disagreement with the statements that they had been able to make something new (S1) and that they had found the app easy to use (S7). It is interesting to note that these two participants self-reported difficulties in both reading books and writing texts (Table 1). This may indicate that, for some users, a combination of reading and writing difficulties might inhibit their use. However, this combination of difficulties did not appear to have a negative impact on the experience for other participants. Participants E, L and M, for example, each indicated strong agreement with the same S1 and S7, in spite of also reporting difficulties with reading and writing. Furthermore, participant M, the only user to report extensive difficulties across all four domains of language, nonetheless reported enjoyment and proficiency. Hence, it appears that users who report a range

of difficulties with language can use *MakeWrite* successfully but further research is required to unpack these findings.

As might be expected, participants identified several additional features that might enhance *MakeWrite* for themselves or others. These included more simplistic text content at the 'Choose' stage; fewer words at the 'Arrange' stage; and the capacity to read-aloud text. Such feedback can inform the design of other apps for constrained creativity which will meet the needs of a variety of users. Finally, the environment – a group workshop – worked for most, but did not for some. Some, with more severe aphasia, reported finding the pace too fast. Beyond this, many noted that they would like to experiment with the app in their own time. Future research should explore the use of *MakeWrite* over the longer term.

6 REFLECTIONS AND WIDER IMPLICATIONS

Use of Automated Constraints for Creativity. The work reported here focuses on providing some automated support for constrained creativity in the context of creative writing. This complements – but diverges from – previous work on creativity support with constraints. Previous work has considered confining the user within a set of parameters (e.g. drawing within lines [2] or keeping in the same key [3]), but has not sought to use these constraints dynamically for content and idea generation. *MakeWrite* encourages users to manipulate and shape the constraints, before allowing for more free-form expression. We believe this design concept, integrated into an accessible, co-designed app as we have here, shows considerable promise.

Ownership of Creative Writing. We discovered some tension relating to the ownership of the texts created with *MakeWrite*. Some workshop participants thought the 'creativity' came from the original source text or the app itself, and not from them. Benedetti et al. [2] note similar findings when testing an app to assist people to make paintings. Like our results, this was attributed to the source (the original painting in their case) and also likely attributed to the algorithm 'doing some of the work', which reduced users' perceived sense of accomplishment.

Such tensions might be addressed in a number of ways. One could consider allowing more control of the parameters within the app or, alternatively, more choice in selecting a source text (or indeed user-generated content). It can be argued that the *source* of the content is an intrinsic part of this class of art-form, and reflects the artistic intent. For some erasure poetry, the source of the content is intended to make a statement. For example, Niina Pollari [38] uses an erasure poetry approach to artistically subvert an official government naturalisation application form to become a US citizen. While such capabilities are possible with *MakeWrite*, the broader issue of source texts was not explored within the workshop. Finally, one might re-imagine the way that the app is presented to the user. It is clear that many viewed the app as an enjoyable challenge. Gamification [14] technology, for example, might motivate people to engage in different ways, foster challenge [22] and therefore deliver a sense of heightened accomplishment in the final result.

Broader Applications. In this paper we have argued that people with aphasia can be enabled to produce creative digital writing through means of automated constrained creativity. Due to the barriers that people with aphasia face, we focused our exploration on the domain of language. However, the ideas proposed may also be considered as a paradigm for wider use. The model is of a stepped process where a user chooses a piece of source content, manipulates it through automated redaction and then dynamically arranges the resultant output. A similar process could reduce the cognitive demand of creative activities in other modalities – sound, video or pictures for example. Lowering the cognitive requirements of writing and other creative activities would open them up to a broader range of users – across a wider age span and a wider cognitive range – and would include those with situational disabilities which temporarily impact upon their cognitive resources.

7 CONCLUSION

As our engagements with creativity become increasingly digital, it is vital to consider the design of technology that can support *everyone* to be creative, such that the domain of artistic expression is accessible to all. Little technology presently supports cognitively diverse groups in fulfilling their creative potential, including those with speech and language impairments such as aphasia. We address this by proposing an approach that uses automated and dynamic constrained creativity. Through co-design with people with aphasia, we developed *MakeWrite*, a prototype app for creative writing based on this concept. *MakeWrite* enables people with aphasia to create meaningful, elegant and sometimes humorous creative writing. We believe that this approach, and the insight we have gained from applying it, offers real potential for designing technology for diverse users to enable more equal access to digital creativity.

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