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Efficacy of clustering and switching strategies in verbal fluency tasks in a Finnish-English language attrition population

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ABSTRACT

Verbal Fluency (VF) task total scores are widely used in language attrition studies, but they do not provide insight into the processes underlying optimal performance. We analyse the efficacy of clustering (subcategories within a category) and switching (shifting between these subcategories) strategies in phonemic (PVF) and semantic (SVF) tasks. First, we focus on L1 Finnish and L2 English performance among attriters ($N = 38$). Our analyses suggest similar processes underlying performance in both languages. These processes seem to remain unaffected by immersion time in the L2 environment (LoR) and frequency of L1 use, highlighting the importance of including L2 data alongside comparisons to L1 monolingual populations to account for a broad bilingual effect in language attrition studies.

Second, we compare attriters' and monolinguals' ($N = 50$) performance in L1. Our findings suggest that attriters rely on clustering in PVF more systematically than monolinguals, and they struggle to initiate a search for a new subcategory or return to a previous category (switching) after depleting a cluster in PVF and SVF tasks. Thus, our analysis demonstrates a difference in processing strategies between the groups that could potentially contribute to similar total scores in PVF and lower total scores in the attriter group in SVF.

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Verbal fluency task; clustering; switching; language attrition

Introduction

Language attrition is a complex phenomenon characterised by subtle alterations in the native language of individuals who are immersed in another language, particularly late sequential bi- or multilinguals. Participants in language attrition studies are typically immigrants who share a history of leaving their native country as young adults after achieving mature L1 proficiency and who have spent a prolonged time in an immersive L2 environment with little exposure to their native language (Schmid 2011b; Schmid 2019; Schmid and Jarvis 2014; Schmid and Köpke 2017). The participants in this study align with the description above. In order to underscore the shared language background of the participants, the terms 'attrition' and 'attriter,' which are the conventional labels for this population, will be used even if the presence of language attrition has not specifically been identified within this group (Kasparian and Steinhauer 2017; Schmid and Köpke 2017).

Many language attrition studies focus on L1 performance of attriters, comparing it solely to that of monolingual speakers of the same L1 (Schmid 2019; Schmid and Dusseldorp 2010; Yilmaz and

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Schmid 2018). However, languages constantly interact in a bidirectional process that influences the cognitive and neural processes of both languages of a bilingual individual (Abutalebi and Green 2007; Grosjean 2013; Gurunandan, Garreiras, and Paz-Alonso 2022; Laine and Lehtonen 2018; Linck and Kroll 2019; Treffers-Daller 2019). Thus, performances in both languages and individuals' exposure to them should be taken into account. In this study, we explore performance in L1 and L2 verbal fluency tasks and the impact of extralinguistic variables on both languages by a group of Finnish immigrants who have resided in an English language environment for over 20 years.

Verbal fluency tasks

Verbal fluency (VF) tasks are widely used to investigate lexical processing in diverse bilingual populations, including those experiencing language attrition. These tasks are simple and quick to administer. During a VF task, the participant is prompted to generate as many items as possible following a specific condition within a set time frame. Typically, the tasks are scored based on the total number of words successfully produced, referred to as total scores. The two most typical VF task types are phonemic verbal fluency (PVF, phonemic, or letter cue, e.g. /f/) and semantic verbal fluency (SVF, semantic category cue, e.g. animals).

When selecting the categories for VF tasks, language and, culture-specific factors should be considered (Abwender et al. 2001; Gollan, Sandoval, and Salmon 2011; Olabarrieta-Landa et al. 2017; Roberts and Dorze 1997; Rosselli et al. 2002). In PVF, letter frequency in the target language can impact the number of words generated, and localising letter prompts to high-frequency word-initial letters in the target language has been shown to result in similar norms across languages (Mardani et al. 2020; Oberg and Ramirez 2006; Schmid 2011a; Tombaugh, Kozak, and Rees 1999). In English, a widely used letter compilation is FAS, selected initially due to the high yield of items for these two consonants and one vowel (Borkowski et al. 1967; Ross 2003; Strauss et al. 2006).

In SVF, various demographic factors and cultural settings can influence semantic memory organisation, semantic category size, and content (Abwender et al. 2001; Olabarrieta-Landa et al. 2017; Roberts and Le Dorze 1997; Rosselli et al. 2002; Strauss et al. 2006; Troyer 2000). Selecting a culturally and linguistically relatively neutral category, such as 'animals' (Pekkala et al. 2009), can stabilise these effects between groups.

All VF tasks require rapid lexical retrieval and inhibition of unsuitable candidates, thus engaging verbal knowledge and executive control skills. PVF tasks rely more on strategic cognitive organisation and maintenance of effort, requiring higher cognitive skills, while SVF tasks rely more on semantic categorisation and hierarchical mental lexicon (Luo, Luk, and Bialystok 2010; Patra, Bose, and Marinis 2020; Schmid 2011a; Strauss et al. 2006). VF task total scores can differentiate performance among various populations and reflect verbal and executive processes underlying task performance. In bilingual research, total scores have been used to infer vocabulary size and access, language dominance patterns, and executive functions during task performance (Luo, Luk, and Bialystock 2010; Marsh et al. 2019; Patra, Bose, and Marinis 2020; Roberts and Le Dorze 1997; Rosselli et al. 2002; Schmid and Köpke 2009).

In PVF tasks, mono- and bilingual groups have shown either similar total scores (Rosselli et al. 2000; Rosselli et al. 2002; Soltani et al. 2021) or bilinguals have outperformed monolinguals (Marsh et al. 2019). Higher scores in the bilingual groups have been associated with enhanced executive functions, potentially stemming from inhibiting language interference while switching between languages (Ljungberg et al. 2013; Luo, Luk, and Bialystock 2010; Marsh et al. 2019; Patra, Bose, and Marinis 2020; Sandoval et al. 2010). Studies that focus on language attrition populations rarely apply PVF tasks (Jarvis 2019; Schmid and Köpke 2009). Some studies suggest a trend of language attriters generating a smaller number of words compared to monolinguals in PVF tasks (Lazaridou-Chatzigoga and Karatsareas 2022; Opitz 2011) contradicting general bilingual findings.

In SVF, bilinguals, including language attriters, systematically generate lower total scores than monolinguals. This bilingual disadvantage has been linked to language interference, weaker

lexical connections, or smaller vocabularies (e.g. Badstübner 2011; Dostert 2009; Gollan, Montoya, and Werner 2002; Opitz 2011; Rosselli et al. 2000; Sandoval et al. 2010; Schmid and Dusseldorp 2010; Schmid and Keijzer 2009; Schmid and Köpke 2009), but VF tasks have been shown to have little effectiveness in distinguishing individuals as attriters or monolinguals (Schmid and Jarvis 2014).

VF task total scores reflect, but do not allow insight into the processes that support or hinder optimal outcomes. Additional analysis methods focusing on temporal parameters, errors, and clustering and switching strategies, have been proposed to further investigate VF data (Lehtinen, Luotonen, and Kautto 2021; Thiele, Quinting, and Stenneken 2016). Following these suggestions, Lehtinen, Kautto and Renvall (2023) analysed VF performance for total scores, temporal parameters (15 second segments), and errors in three PVF tasks (letters: L1 /k/,/a/, /p/; L2 /f/, /a/, /s/) and one SVF category ('animals') in a group of Finnish-English language attriters and Finnish monolinguals. The current study further extends the analysis of this VF task performance via clustering and switching analysis. In the following, we provide a brief overview of the previous literature on clustering and switching strategies in the context of bilingual verbal fluency tasks before describing the current study in detail.

Clustering and switching

In VF task analysis clustering refers to the ability to form sub-clusters in a category (e.g. in the category 'animals': farm animals – pets – wild animals), and switching is the ability to transition between these clusters (e.g. shifting from farm animals to pets to wild animals). Productive performance in a VF task involves both clustering and switching strategies, typically measured respectively as the mean cluster size and the number of switches. Various methods can be employed in determining clusters and switches, and the technique used to compute clusters also influences the number of transitions between those clusters. Thus, direct comparisons across studies employing different methods should be made with careful consideration (Lehtinen, Kautto, and Luotonen 2021; Strauss et al. 2006; Thiele, Quinting, and Stenneken 2016; Troyer 2000; Troyer, Moscovitch, and Winocur 1997).

Task congruent clusters in PVF, namely phonemic clusters, are based on phonemic characters, such as the same onset-nucleus sequence as in 'simple, simile, sieve'. Generating phonemic clusters requires a cognitively effortful non-routine search based on phonemic attributes without the help of semantic categorisation (Luo, Luk, and Bialystock 2010; Strauss et al. 2006; Troyer 2000; Troyer, Moscovitch, and Winocur 1997). In SVF, generating task-congruent clusters (semantic clusters) involves verbal semantic memory and semantic categorisation, resembling a relatively spontaneous everyday systematic semantic search, such as generating a shopping list. The transition between the clusters (i.e. switching), involves higher executive functions, including cognitive flexibility (Thiele, Quintin, and Stenneken 2016; Troyer, Moscovitch, and Winocur 1997; Troyer 2000). Consequently, Troyer, Moscovitch, and Winocur (1997) showed that in a monolingual population, switching was more crucial for optimal fluency than task-congruent clustering in PVF, while in SVF, both clustering and switching strategies were more equally important in reaching a high total score.

In addition to task congruent clusters, task-discrepant clustering (semantic clusters in PVF and vice versa) represents an additional effortful and often intentional strategy. It involves higher cognitive processes than task-congruent clustering and can suggest the activation of semantic mechanisms in an effortful phonemic task (Abwender et al. 2001; Sung et al. 2013).

Within the field of bilingualism, clustering and switching strategies have been analysed to study executive processes (Mardani et al. 2020; Marsh et al. 2019; Patra, Bose, and Marinis 2020) and cross-linguistic fluency strategies (Roberts and Le Dorze 1997; Rosselli et al. 2002). It has also been suggested that bilinguals, who regularly switch between languages in everyday life, may demonstrate superior cognitive flexibility through more efficient switching strategies than monolinguals (Gollan, Montoya, and Werner 2002).

However, many studies include only one of the participants' languages, and the various methods used to calculate clusters and switches can complicate the interpretation of the findings. For

example, Patra, Bose, and Marinis (2020) studied the L2 performance of Bengali-English bilingual immigrants (time spent in L2 environment $M = 7.48$ years) and showed that bilinguals generated larger clusters than monolinguals in PVF, resulting in a higher total score, and groups performed similarly in SVF. They suggested that the ability to maintain a more demanding strategy of PVF clustering better than monolinguals could signal superior executive performance in the bilingual group. In contrast, Mardani et al. (2020) reported a higher total score but no significant difference in L1 PVF cluster size between monolinguals and self-reported Farsi-Balochi bilinguals with no sudden change in their language environment. Thus, bilinguals relied more on switching to reach a higher total score than monolinguals. In SVF, bilinguals generated smaller clusters than monolinguals in L1 with no significant difference in total scores, interpreted as a disadvantage in verbal-semantic memory performance in the bilingual group.

As for studies investigating language attrition populations per se, we are not aware of a robust VF task clustering and switching analysis. Ammerlaan (1996) notes that attriters rely heavily on effortful strategies in VF but does not include an analysis of these strategies in his study.

When determining clusters and switches in bilingual populations, it is important to consider varied language backgrounds. Roberts and Le Dorze (1997) studied L1 and L2 in a French-English bilingual group and reported larger semantic clusters in L1 than in L2 in the category 'animals' but not 'foods'. They suggested that as the names of animals were learned during childhood when the participants were exposed primarily to L1, there may be a stronger semantic base in L1 for 'animals' than 'foods', since food-related words are typically learned later in life when the participants had more exposure to L2. Rosselli et al. (2002) also observed that differences in the semantic clustering of two monolingual groups were less evident in English-Spanish bilinguals (specifically that English monolinguals named more wild animals and Spanish monolinguals more birds and insects). The authors interpreted this as indicating different semantic category structures between bilingual and monolingual groups.

In clustering analysis, language-specific factors can be taken into consideration by analysing naturally occurring clusters rather than using predetermined categories, especially in SVF (Abwender et al. 2001; Gollan, Sandoval, and Salmon 2011; Lehtinen, Luotonen, and Kautto 2021; Olabarrieta-Landa et al. 2017; Roberts and Dorze 1997; Rosselli et al. 2002). Naturally occurring semantic subcategories can include taxonomic subcategories (e.g. wolf, dog), environmental (e.g. gazelle, lion), geographical (e.g. wombat, kangaroo), or visual semantics (e.g. snake, eel) in the semantic category. In the phonemic category, these can include, e.g. two initial phonemes (e.g. fossil, foster) or rhyming words (e.g. fight, flight). For a more detailed discussion on naturally occurring clusters, we refer the reader to the VF task administration and analysis guide in Lehtinen, Luotonen, and Kautto (2021).

Extralinguistic variables

Sociolinguistic parameters, such as language exposure and use, can result in shifts in individual language dominance patterns over time affecting language performance (Treffers-Daller 2019; Yilmaz 2019). As language attrition populations share a history of prolonged immersion in an L2 environment with minimal exposure to their native L1 over an extended time (Schmid 2011b; Schmid 2019; Schmid and Jarvis 2014; Schmid and Köpke 2017), in this study we focus on two variables that reflect the participants' shared language history and may have a direct effect on language attrition: length of residence in the L2 environment (LoR) and frequency of L1 use during that time.

Research shows that in general, LoR typically affects L1 language task performance during the initial years of residence, while L2 is simultaneously rapidly acquired, with the effect typically levelling out after the first decade (Linck and Kroll 2019; Opitz 2011; Schmid 2011b; Schmid 2019). The impact of LoR may also become significant when combined with very little L1 use (de Bot and Clyne 1994).

The frequency of L1 use as a single measure has not been found to systematically impact L1 performance (for an overview, see Schmid 2019). However, L1 use in professional settings has been shown to positively impact lexical retrieval and lexical diversity in L1 (Schmid and Dusseldorp

2010; Yilmaz and Schmid 2012). In addition, frequent L1 use in informal settings with peers has been shown to contribute to increased variability in the phonemic domain, potentially suggesting contact-induced language change in the community rather than at the individual level (De Leeuw, Schmid, and Mennen 2010).

In previous studies on language attrition, VF total scores have been largely unrelated to the time spent in an L2 environment (LoR) or frequency of L1 use (Schmid 2011a; Schmid and Jarvis 2014; Schmid and Köpke 2009). In this study, we investigate the impact of LoR, frequency of L1 use, and their interactions on the efficacy of clustering and switching in PVF and SVF among a group of language attriters to better understand the impact extralinguistic variables have on the processes underlying VF task performance.

Research objectives, questions, and hypotheses

The present study examines the effectiveness of clustering and switching strategies in phonemic (PVF) and semantic (SVF) verbal fluency tasks among Finnish-English bilinguals who have experienced prolonged immersion in an English-speaking environment, thus considered attriters. First, we examine VF task performance in their first (L1, Finnish) and second language (L2, English) and assess the influence of the length of residence (LoR) and frequency of L1 use on the use of clustering and switching. Second, we compare L1 task performance between attriters and L1 monolinguals to investigate differences in the efficacy of clustering and switching between the groups. Our research questions and hypotheses are as follows:

Research question 1: L1 and L2 within the attriter group

(a) Do task-congruent mean cluster size and the number of switches predict total score similarly for the attriters in L1 and in L2 in PVF and SVF tasks?
(b) Does LoR, the frequency of L1 use, and their interactions impact the efficacy of clustering and switching strategies within the group?

Hypothesis: We expected attriters to demonstrate a robust semantic network in L1 by relying more efficiently on clustering than switching in L1 compared to L2. We anticipated frequent L1 use to support switching in both languages and task types, potentially reflecting cognitive flexibility stemming from more frequent L1 use in an L2-dominant environment.

Research question 2: L1 in the attriter and monolingual groups

Do task-congruent mean cluster size and the number of switches predict total score similarly in the attriter and monolingual groups for L1 PVF and SVF tasks?

Hypothesis: We expected attriters to demonstrate superior executive flexibility by relying more on switching than monolinguals in PVF. In SVF, we anticipated attriters to display a weaker semantic foundation and greater cognitive flexibility than monolinguals by relying less on clustering and more on switching strategies.

Materials and methods

Participants

Two groups of healthy, neurotypical adults participated in this study: L1 attriters ($N = 38$, L1 Finnish, L2 English) and Finnish monolinguals ($N = 50$). Attriters were first-generation immigrants living in Northern California who had immigrated from Finland between 1948 and

1998 [age $M = 60.89$, $SD = 8.42$, range 45–79; education: no academic degree ($n = 16$) and academic degree ($n = 22$), gender: female ($n = 29$) and male ($n = 9$)]. Attrition-specific data is referenced in Table 1.

The monolingual participants identified themselves as monolinguals who had always lived in Finland and used only Finnish in their everyday life [age $M = 62.58$, $SD = 7.59$, range 49–79, education: no academic degree ($n = 27$) and academic degree ($n = 23$), gender: female ($n = 35$) and male ($n = 15$)]. The groups were matched for age, education (no academic degree/academic degree), and gender with no significant differences detected for age (attriters $M = 60.90$, monolinguals $M = 62.60$) $z = -0.97$, $p = .332$, education ($\chi(1) = 0.49$, $p = .27$), or gender ($\chi(1) = 0.43$, $p = .51$) between the groups.

Administration and analyses of data

Task administration, scoring, and analyses were conducted following guidelines in Lehtinen, Luotonen, and Kautto (2021). For clarity, we briefly describe the methods below.

During administration, participants were asked to generate as many words as possible in a 60-second time frame following the given criteria. The only exclusion was proper names and instructions included the phrase 'individual words' to discourage participants from generating inflections of the same word in Finnish [e.g. *kirja* (book), *kirjassani* (in my book)].

L1 language-appropriate phonemic prompts /k, /a/, /p/ were selected following a high-frequency dictionary approach for two consonants and one vowel to correspond to L2 letter selection (Lehtinen, Luotonen, and Kautto 2021; Mardani et al. 2020; Oberg and Ramirez 2006; Schmid 2011a). For L2 PVF, letters /f/, /a/, /s/ were selected based on their frequent use in the literature (Borkowski et al. 1967; Ross 2003; Strauss et al. 2006). For the SVF, we selected the culturally and linguistically relatively neutral category 'animals' (Pekkala et al. 2009).

We calculated the mean cluster size for naturally occurring semantic clusters in SVF and the mean cluster size for naturally occurring phonemic clusters in PVF. The minimum cluster size was two words. The number of switches was based on the task- congruent clusters. Our preliminary analysis showed that task-discrepant clusters (semantic clusters in PVF and vice versa) occurred only rarely in the data. Due to the small sample size, analysis for task-discrepant clusters was omitted, but the data is included in the data repository of this study.

Extralinguistic factors were extracted from a sociolinguistic questionnaire and included self-reported length of residence in an L2 environment in years (LoR) and overall frequency of L1 use during that time [How often do you speak Finnish? 5-point Likert scale: rarely ($n = 1$), few times a year ($n = 1$), monthly ($n = 7$), weekly ($n = 22$), daily ($n = 7$)].

R software (R Core Team 2019) with packages dplyr (Wickham et al. 2019), tidyr (Wickham 2020), lme4 (Bates et al. 2015), and lmerTest (Kuznetsova, Brockhoff, and Christensen 2017) were used in data clean-up and analyses. Packages sjPlot (Lüdecke 2018), jtools (Long 2020), ggeffects (Lüdecke 2018), and ggplot2 (Wickham 2016) were used in tables and figures. Scripts and data used for the analyses are available at https://osf.io/95q3j/.

Table 1. Age at emigration, length of residence in L2 environment, frequency of L1 use, and self-reported language proficiency in L1 and L2 in the attriter group ($N = 38$).

	M	Range	*SD*
Age at emigration	26.68	9–48	7.38
Length of residence in L2 environment	34.24	20–50	10.83
	Very good	*Good*	*Good enough to get by*
Self-report on L1 before emigration	23	15	0
Self-report on L1 at the time of interview	6	26	6
Self-report on L2 at the time of interview	21	16	1

Statistical analyses

For comparison between the efficacy of clustering and switching strategies in L1 and L2 within the attriter group, we used linear mixed-effects models to predict total scores as a function of task-congruent cluster size, the number of switches and language (L1/L2) separately for PVF and SVF with LoR and L1 use as predictors. Cluster size and the number of switches were centred to the sample mean. Participant ID was used as a random factor to account for individual variation in performance. Comparisons of Bayesian Information Criterion (BIC) values in models with and without LoR as a predictor suggested the models without LoR to be the most parsimonious fits to the data.

To compare the L1 performance in the attriter and monolingual groups, we modelled total scores as a function of task-congruent cluster size, the number of switches, and the participant group separately for PVF and SVF. As our PVF task data included three observations for each participant (/k/, /a/, and /p/), participant ID was used as a random factor in that model.

Results

Descriptive statistics for total scores in L1 and L2 in the attriter group and L1 in the monolingual group are shown in Table 2.

Research question 1: L1 and L2 within the attriter group

The model summaries, including estimates, *t*-values, and *p*-values for PVF are presented in Table 3, and for SVF in Table 4. For both tasks, we found significant main effects for mean cluster size and the number of switches with higher total scores linked to efficient use of clustering and switching strategies. We found no significant interactions for task language or frequency of L1 use. The relationship between clustering and switching was consistent in L1 and L2 for both task types, and the frequency of L1 use did not modify the use of clustering and switching within the attriter group.

Research question 2: L1 in the attriter and monolingual groups

The model summary for switching and clustering in the PVF task is presented in Table 5. A significant interaction between group and cluster size was observed, but no significant interaction was detected for the number of switches and group. The stronger relationship between cluster size and the total score in the attriter group compared to the monolingual group is shown in Figure 1.

The Model summary for switching and clustering in the SVF is presented in Table 6. We discovered a significant interaction between group, cluster size, and the number of switches. Figure 2 shows the relationship between cluster size and the total score becoming weaker as the number of switches increases in the monolingual group, while in the attriter group, the connection between cluster size and the total score remains consistent regardless of the number of switches.

Table 2. Descriptive data for total scores in L1 and L2 in the attriter Group and L1 in the monolingual group.

	L1				L2			
	k	a	*p*	animals	f	a	s	animals
Attriters								
Mean	18.92	14.90	16.45	21.90	14.05	10.60	15.32	20.60
SD	4.94	5.03	4.54	4.31	4.23	5.13	5.21	4.85
Range	11–33	6–24	7–27	13–33	7–27	1–20	6–28	9–32
Monolinguals								
Mean	19.38	14.68	17.44	25.96				
SD	6.12	5.65	5.50	5.90				
Range	5–35	5–31	4–30	12–43				

Note. L1 attriters $N = 38$; L2 attriters $N = 37$; L1 monolinguals $N = 50$. Overall VF performance and performance changes during the tasks were previously reported in Lehtinen, Kautto, and Renvall (forthcoming) for attriters and in Lehtinen, Luotonen, and Kautto (2021: 1–13) for the monolingual group.

Table 3. Phonemic Verbal Fluency task total scores as a function of task-congruent cluster size, the number of switches, and language (L1/L2) in the attriter group.

	Total score			
Predictors	Estimates	95% CI	*t*	*p*
(Intercept)	14.66	13.95–15.38	40.29	<0.001
Number of switches	3.92	3.28–4.56	12.04	<0.001
Mean cluster size	2.17	1.40–2.94	5.56	<0.001
Task language	0.72	−0.08–1.51	1.78	0.08
Frequency of L1 use	0.57	−0.23–1.36	1.41	0.16
Number of switches* Mean cluster size	0.02	−0.62–0.67	0.06	0.95
Number of switches* Task language	−0.56	−1.39–0.28	−1.31	0.19
Mean cluster size* Task language	0.51	−0.49–1.50	1.01	0.32
Number of switches* Frequency of L1 use	0.16	−0.59–0.91	0.43	0.67
Mean cluster size* Frequency of L1 use	0.43	−0.25–1.11	1.24	0.22
Task language* Frequency of L1 use	0.33	−0.54–1.2	0.75	0.46
Number of switches* Mean cluster size* Task language	0.09	−0.80–0.99	0.21	0.84
Number of switches* Mean cluster size* Frequency of L1 use	0.01	−0.65–0.68	0.03	0.97
Number of switches* Task language* Frequency of L1 use	0.03	−0.89–0.96	0.07	0.94
Mean cluster size* Task language* Frequency of L1 use	0.49	−0.43–1.40	1.05	0.30
Number of switches* Mean cluster size* Task language* Frequency of L1 use	0.29	−0.63–1.22	0.63	0.53
Random effects				
σ^2	6.77			
τ00 ID	1.81			
ICC	0.21			
N_{ID}	38			
Observations	*225*			
Marginal R^2 / Conditional R^2	*0.697 / 0.761*			

Discussion

Verbal fluency tasks are one of the most utilised tasks in language attrition studies (Schmid 2019). However, their analyses are typically limited to total scores, offering little insight into the processes underlying task performance. In the current study, we extended the analyses of VF task performance

Table 4. Semantic Verbal Fluency task total scores as a function of task-congruent cluster size, the number of switches, and language (L1/L2) in the attriter group.

	Total score			
Predictors	Estimates	95% CI	*t*	*p*
(Intercept)	21.08	20.09–22.07	42.64	<0.001
Number of switches	3.56	2.49–4.64	6.64	<0.001
Mean cluster size	2.43	1.44–3.43	4.90	<0.001
Task language	0.87	−0.42–2.16	1.36	0.18
Frequency of L1 use	1.09	−0.06–2.23	1.90	0.06
Number of switches* Mean cluster size	0.33	−0.88–1.53	0.55	0.59
Number of switches* Task language	−0.64	−2.10–0.82	−0.87	0.39
Mean cluster size* Task language	−0.89	−2.43–1.66	−1.15	0.26
Number of switches* Frequency of L1 use	−0.13	−1.34–1.08	−0.22	0.83
Mean cluster size* Frequency of L1 use	−0.57	−1.85–0.72	−1.88	0.38
Task language* Frequency of L1 use	0.55	−1.08–2.18	0.68	0.50
Number of switches* Mean cluster size* Task language	0.65	−0.92–2.21	0.83	0.41
Number of switches* Mean cluster size* Frequency of L1 use	−0.37	−1.84–1.10	−0.51	0.62
Number of switches* Task language* Frequency of L1 use	0.27	−1.41–1.96	0.33	0.75
Mean cluster size* Task language* Frequency of L1 use	1.18	−0.90–3.27	1.14	0.26
Number of switches* Mean cluster size* Task language* Frequency of L1 use	1.88	−0.44–4.21	1.62	0.11
Random effects				
σ^2	5.71			
τ00 ID	1.25			
ICC	0.18			
N_{ID}	38			
Observations	75			
Marginal R^2 / Conditional R^2	0.689 / 0.745			

Table 5. Phonemic Verbal Fluency task total scores as a function of task-congruent cluster size, the number of switches, and participant group in the attriter and monolingual groups.

	Total score			
Predictors	Estimates	95% CI	*t*	*p*
(Intercept)	16.93	16.06–17.80	38.39	<0.001
Group [monolingual]	−0.01	−1.16–1.13	−0.02	0.98
Number of switches	3.93	3.18–4.67	10.38	<0.001
Mean cluster size	3.51	2.42–4.60	6.34	<0.001
Group [monolingual]* Number of switches	−0.26	−1.16 - 0.63	−0.58	0.56
Group [monolingual]* Mean cluster size	−1.53	−2.74 – −0.33	−2.51	0.013
Number of Switches* Mean cluster size	0.55	−0.26–1.37	1.33	0.18
Group [monolingual]* Number of switches* Mean cluster size	−0.72	−1.61–0.17	−1.59	0.11
Random effects				
σ^2	5.88			
τ00 ID	5.17			
ICC	0.47			
N_{ID}	88			
Observations	264			
Marginal R^2 / Conditional R^2	0.603 / 0.789			

Phonemic Verbal Fluency Task Total Scores as a Function of Task-Congruent Cluster Size, the Number of Switches, and Participant Group in the Attriter and Monolingual Group.

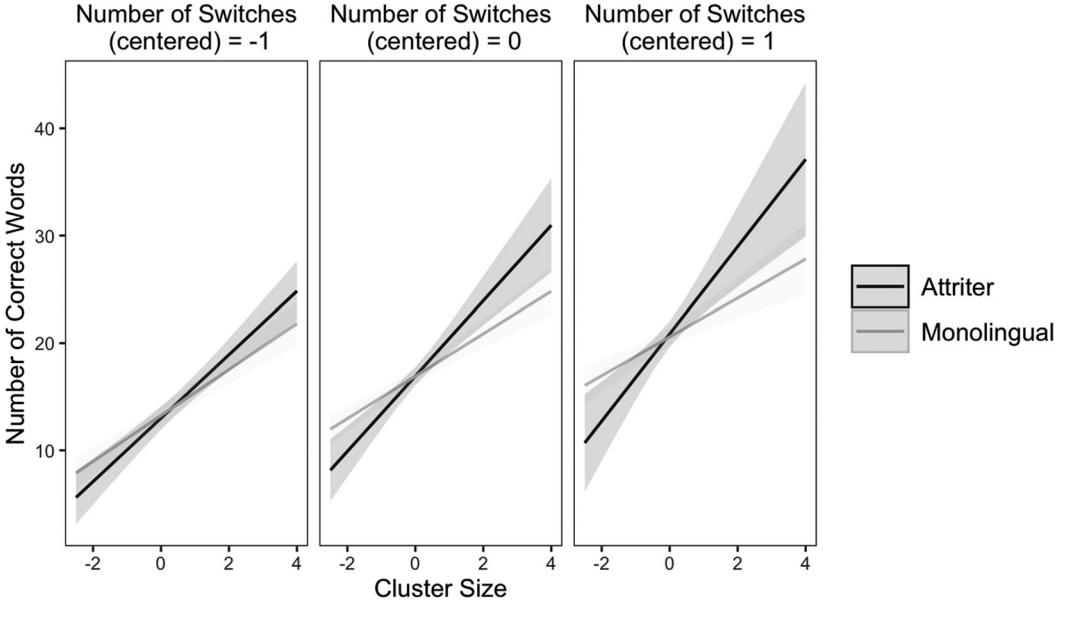

Figure 1. Total scores as a function of task-congruent cluster size (centred), the number of switches (centred), and participant group in the Phonological Verbal Fluency task.

to the efficacy of clustering and switching strategies in three phonemic (PVF) and one semantic (SVF) verbal fluency tasks. Our first objective was to explore processes that support optimal performance in L1 and L2 in a group of Finnish-English language attriters and to investigate the influence LoR and frequent L1 use has on these processes. We then set out to determine if the processes of optimal VF task performance differ between attriters and L1 monolinguals.

We expected attriters to rely more efficiently on clustering in L1 than L2 as a marker of a more robust semantic network in L1. Contrary to our expectations, attriters utilised clustering and switching strategies equally efficiently to reach a high score across languages and tasks. Thus, the performance in L1 and L2 SVF and PVF tasks mirrors typical, monolingual SVF performance where both

Table 6. Semantic Verbal Fluency task total scores as a function of task-congruent cluster size, the number of switches, and participant group in the attriter and monolingual groups.

	Total score			
Predictors	Estimates	95% CI	*t*	*p*
(Intercept)	23.44	22.21–24.66	38.17	<0.001
Group [monolingual]	1.39	−0.18–2.95	1.76	0.08
Number of switches	3.59	2.31–4.88	5.58	<0.001
Mean cluster size	3.08	1.64–4.52	4.27	<0.001
Group [monolingual]* Number of switches	0.79	−0.80 - 2.39	0.99	0.33
Group [monolingual]* Mean cluster size	−1.36	−3.05–0.33	−1.61	0.11
Number of switches* Mean cluster size	0.72	−0.69–2.13	1.02	0.31
Group [monolingual]* Number of switches* Mean cluster size	−2.12	−3.85 – −0.40	−2.45	0.017
Observations	264			
Marginal R^2 / Conditional R^2	0.603 / 0.789			

Note: Descriptive data for total scores in both languages and groups is shown in Table 2.

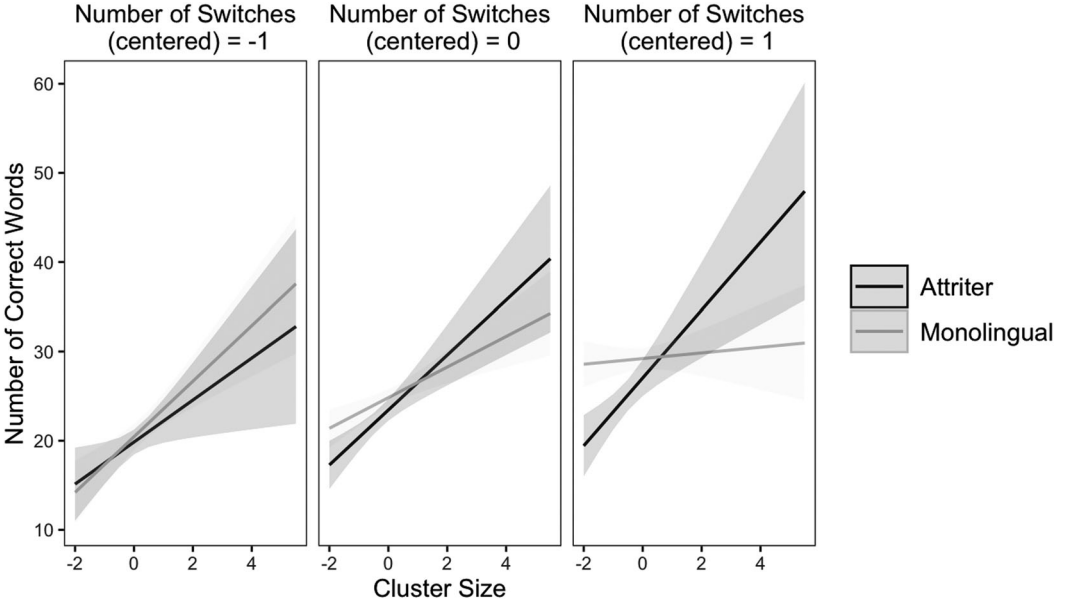

Figure 2. Total scores as a function of task-congruent cluster size (centred), the number of switches (centred), and participant group in the Semantic Verbal Fluency task.

strategies contribute equally to a high score as reported by Troyer, Moscovitch, and Winocur (1997). This finding is discussed below in relation to the performance of the monolingual group. Our findings of similar performance in L1 and L2 point to the direction of a general bilingual effect in VF task performance across languages rather than L1 language attrition among attriters. Consequently, our results highlight the importance of investigating performance in both languages in language attrition studies to account for the broad impact bidirectional cognitive and neural processes of bilingualism can have on the linguistic performance of a bilingual individual as a whole (Abutalebi and Green 2007; Gurunandan, Carreiras, and Paz-Alonso 2022; Laine and Lehtonen 2018; Schmid and Köpke 2017).

Our first research question also addressed the impact of LoR and frequency of L1 use on strategies that underlie task performance. These extralinguistic variables did not appear to contribute to the efficacy of either strategy. In future research, analysing task-discrepant clusters and extralinguistic factors' influence on their occurrence in L1 and L2 can offer insight into the impact of extralinguistic factors on processing strategies between languages.

To answer our second research question, we investigated differences in the efficacy of clustering and switching strategies in L1 task performance between attriters and L1 monolinguals. Based on the literature, we anticipated that attriters would demonstrate a cognitive advantage by relying more on switching than monolinguals in PVF. However, we detected no significant differences in the effectiveness of switching strategies between the groups. On the contrary, in PVF attriters seemed to be able to maintain the effortful cognitive strategy of generating task-congruent phonemic clusters more efficiently than monolinguals. Our results align with Patra, Bose, and Marinis (2020), who interpreted their finding of larger task-congruent clusters in the bilingual group as superior executive functions compared to a monolingual group. In the current study, we similarly infer that rather than relying on switching (i.e. returning to a previous subcategory or initiating a new subcategory when a subcategory has been depleted), attriters generated larger clusters to reach a similar total score as monolinguals in PVF. In line with this finding, a comparison between L1 and L2 performance among the attriters showed that attriters rely more equally on clustering and switching in PVF than anticipated in both languages.

The phenomenon of attriters relying on clustering for optimal performance was also apparent in SVF, where the connection between cluster size and the total score remained consistent in the attriter group regardless of the number of switches. In contrast, monolinguals used clustering and switching strategies more equally to achieve higher scores, in line with Troyer, Moscovitch, and Winocur (1997). Thus, our findings underscore that while monolinguals were able to support their performance by switching between categories and clustering, support from switching between the categories was less efficient for optimal performance in the attriters group and these tendencies were reflected in L2 performance.

Our results for PVF align partly with Patra, Bose, and Marinis (2020), where bilinguals generated higher total scores in their L2 by relying on larger clusters than monolinguals. While their study did not address language attrition per se, their participants were immigrants who had spent a significant time in an immersive L2 environment ($M = 7.48$ years). In contrast, Mardani et al. (2020) found that bilinguals with no sudden change in their language environment relied more on switching than clustering, generating a higher total score than monolinguals in L1 PVF. They also report that bilinguals generated smaller clusters in L1 SVF, resulting in similar total scores with monolinguals. When interpreting these findings, it is important to note that there are various methods for determining clusters and, consequently, the number of switches between these clusters. Both Patra, Bose, and Marinis (2020) and Mardani et al. (2020) used predetermined cluster categories in their analysis, but scarce details were given of their specific analysis. We calculated the size of naturally occurring task- congruent clusters to include all unique clustering strategies and natural switches generated by participants without the constraints of predetermined semantic categories (Lehtinen, Luotonen, and Kautto 2021; Roberts and Dorze 1997; Rosselli et al. 2002).

Thus, comparison across these studies requires careful consideration. In addition, the relatively small study samples and different language pairs call for further consideration when generalising our results. However, we remain confident that our analysis based on well-defined guidelines on analysing naturally occurring clusters and switches offers a solid foundation and direction for future studies involving larger data sets, diverse language pairs, and various language contact situations. Future comparative studies between attriters and bilinguals with no change in their language environment could also determine the role of extralinguistic circumstances in the use of clustering and switching in VF tasks across bilingual populations.

We set out to investigate the processes that support or hinder optimal outcomes within a Finnish-English language attrition population L1 and L2 VF task performance and between attritters and L1 monolinguals. Our results demonstrate that an extended VF task analysis has the potential to yield insight into the subtle language processes underlying VF task performance and provide a solid starting point for future studies to further investigate the similarities in language attrition populations in contrast to monolinguals and bilinguals with varied backgrounds.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data supporting this study's findings are available in [Verbal Fluency Switching and Clustering in Language Attrition] at [https://osf.io/95q3j].ote.

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