



When music compensates language: a case study of severe aphasia in dementia and the use of music by a spousal caregiver

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ABSTRACT

Background: There is accumulating evidence of the preservation of music skills in people with Alzheimer's dementia (AD), including spared memory for familiar music and the ability to produce music by singing or playing an instrument. Music can also be used to alleviate symptoms of dementia, leading to reduced agitation, improved positive mood, memory, and expressive language functions.

Aims: We evaluated the rate of decline of expressive language and music skills in TC, a 77 year old woman with aphasia in the context of severe AD, and her husband's use of music in caregiving. Neither TC nor her husband had any formal music training. We also explored whether the preservation of music skills had implications for treating a symptom of her dementia, specifically her misidentification delusion.

Methods & Procedures: A retrospective comparison of the progressive decline in TC's expressive music and language skills was obtained through interviews with her husband. He also completed a purposefully developed questionnaire regarding his use of music during caregiving. Assessment of TC's language skills was attempted using the *Sydney Language Battery*, and her music engagement skills were evaluated with the *Music Engagement Questionnaire* (MusEQ, informant version). Her behaviour and verbal communication was observed during four different conditions, presented by her husband; (1) reading a newspaper article, (2) reading familiar song lyrics, (3) singing familiar song lyrics, and (4) listening to the original version of the familiar song.

Outcomes & Results: TC exhibited a gradual deterioration of her expressive language abilities, whereas her music skills (singing and music engagement), were relatively preserved. Her overall score on the MusEQ was in keeping with age matched healthy controls (50–55 percentile) and she had a high average (80–85 percentile) score on the "emotion" subscale. The impact of preserved music engagement was powerfully demonstrated when TC developed a transient misidentification delusion and believed that her husband was an intruder. Her delusion was only resolved after her husband repeatedly sang a significant song that they had shared as a couple for close to 60 years. By singing this special song ("Unchained Melody"), TC eventually "came back" and recognised

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him. During behavioural observations under different language and music conditions, TC's verbal communication did not appear to change.

Conclusions: This case study illustrates that when language skills deteriorate in AD, music functions may persist, providing a vital tool in coping with the symptoms of severe dementia.

1. Introduction

Aphasia is a common symptom of various types of dementia, including the most common type, Alzheimer's dementia (AD). It is the hallmark symptom of other types of dementia such as Primary Progressive Aphasia (PPA) and other language variants of Frontotemporal dementia, in which there is a progressive language impairment, affecting both expressive and receptive language skills (Gorno-Tempini et al., 2011; Harciarek & Kertesz, 2011). There are anecdotal reports of expressive music skills, in particular singing ability, persisting long after the decline of expressive language skills in people with dementia. Observations include people who are typically unresponsive suddenly singing familiar song lyrics. This dissociation between expressive music and language skills has been well documented in people with aphasia due to stroke, but has received far less attention in people with dementia.

Polk and Kertesz (1993) described a double dissociation between music and language skills as demonstrated by two musicians with dementia. The first case, a male guitarist with PPA showed a dissociation between music and language in fluency and content. His music production was considered continuous and organised, which contrasted with his non-fluent language. In contrast, the second case showed the opposite pattern of deficits. A female piano teacher with posterior cortical atrophy who was not aphasic showed severe expressive music deficits with impaired melody and rhythm organization that was contrasted with fluent, intelligible language. A decade later, Warren, Warren, Fox, and Warrington (2003) explored vocal expression in verbal and music domains in a man with primary progressive dynamic aphasia. In a series of novel tasks involving high and low probability sentences and musical sequences, they found a striking dissociation between his impaired verbal output and spared ability to produce novel musical output. These cases demonstrate how expressive language and music functions can functionally dissociate in the face of dementia.

There have been reports of an increase in expressive language in response to music in people with dementia. For example, in a personal communication to us, a woman who cares for her 89 year old mother with severe dementia stated that she

usually sits with her head hanging low and is unresponsive, but when she listens to music or I sing to her, she starts to bang her hands on her legs, smile and laugh. Christmas songs are her favourite and sometimes she blurts out a word or two.

An Australian documentary entitled "Music on the Brain" (ABC TV Catalyst) included an aged care facility manager who commented on the response of a woman with severe

dementia after she listened to her favourite music: "I was stunned at the conversation that she had (after the music). It was actually a coherent conversation. It wasn't muddled... I didn't expect that to happen". The documentary "Alive Inside" also captured powerful examples of this phenomenon, with the most famous case of Henry, a man with dementia, demonstrating a striking expressive language response to hearing one of his favourite songs.

A number of small-scale studies have investigated the impact of music on expressive language functions in people with dementia, although limitations of these studies include small sample sizes and minimal language assessment. The findings of these studies are summarised in [Table 1](#). Notably, all five studies reported improved language functions after the music activity, despite methodological differences between the studies (including the type, frequency and length of music activity and comparison/control activity, the language functions assessed and measures used, the timing of assessments, and the type of dementia of participants). Therefore, the findings to date appear to support anecdotal evidence of enhanced expressive language functions in response to music in people with dementia.

A number of potential mechanisms may underlie the phenomenon of improved expressive language in response to music in people with dementia. First, if music and language are associated with shared neural resources, then activation of brain regions by music could facilitate language function. For example, activation of shared syntactic resources by music could potentially enhance syntactic processing in both productive and receptive language, thereby improving the fluency of linguistic communication (Patel, 2011; Steinbeis & Koelsch, 2011; Van de Cavey & Hartsuiker, 2016). Second, music may enhance language function by activating neural responses to acoustic features that are important in both music and language, such as pitch and rhythm (Jungers, Hupp, & Dickerson, 2016; Patel, 2011; Przybylski, 2013). Such acoustic attributes function in both music and language to signal important events (accents) and to clarify phrase structure. Third, music may help to enhance mood and motivation. Enhanced mood following exposure to music is known to facilitate cognitive function (Ilie & Thompson, 2011; Thompson, Schellenberg, & Husain, 2001), and this benefit may extend to language function.

Insights can also be gained from the extensive work on formal music-based treatments for post stroke aphasia, in particular melodic intonation therapy (MIT). The observed benefits of MIT may be underpinned by various mechanisms, including the promotion of functional and structural neuroplastic reorganisation of language functions, activation of the mirror neuron system, and multimodal integration (Merrett, Peretz, & Wilson, 2014). Neural reorganisation of language functions in response to music is unlikely to occur in people with dementia, but the other proposed mechanisms warrant further investigation in this population. While MIT is a formal structured therapy utilising singing, informal uses of singing may result in similar benefits in people with dementia, and this case study aimed to describe one instance of this possibility.

In addition to the reported beneficial effects of music on expressive language in people with dementia, there is emerging evidence of the positive effects that music has on other functions such as memory, mood, and behaviour (see Baird & Samson, 2015 for a review). It is clear, however, that more research is needed, because a recent systematic review of randomised control trials (RCTs) of music interventions for symptoms of



Table 1. A summary of the findings of studies measuring the impact of music interventions on language skills in people with dementia.

Study	Intervention				Sample			Language Assessment		Main findings	
	Type	Length (mins.)	Sessions/week	Total duration	Control	N	Type	Severity of dementia	Tool		Time of assessment
Brottons and Koger (2000) ^a	Music therapy (MT): Songs with guitar, topics of animals, flowers, spring, St Patrick's day, USA.	30	2/week	4 weeks	Conversation with pictures based on same topics in MT group.	20 (15 F)	AD	MMSE mean = 10 Mild = 1, Moderate = 12 Severe = 1 Profound = 6	WAB	Baseline, 2 weeks post intervention.	MT greater improvement in speech content and fluency dimensions of spontaneous speech subscale of WAB ($p = .01$).
Suzuki et al. (2004) ^b	MT: Singing songs, playing percussion.	60	2/week	8 weeks	Games, drawing and pasting pictures.	MT: 10 (6 F) Control: 13 (9 F)	MT: AD = 6 Vascular = 5 Control: AD = 6 Vascular = 7	MMSE mean = 14.8 Control: MMSE mean = 13.4	MMSE	Baseline, 1 week post intervention.	Language subscale of MMSE improved significantly in MT group from mean 5.30 to 6.40 ($p = .01$).
Hong and Choi (2011) ^b	Song-writing	60	1/week	16 weeks	Free time	30 (28 F) Music = 15 Control = 15	AD = 26 Parkinson's = 1 Vascular = 3	MMSE-Korean version (K) mean = 14.8	MMSE-K	Baseline, 1 week post intervention.	Language subscale scores on MMSE-K increased in MT group from 2.80 to 3.93 ($p < .01$)

(Continued)

Table 1. (Continued).

Study	Intervention			Sample			Language Assessment			
	Type	Length (mins.)	Sessions/week	Control	N	Type	Severity of dementia	Tool	Time of assessment	Main findings
Särkämö et al. (2014) ^a	Singing or listening to familiar songs. Vocal exercises and rhythmic movements (singing control) or, discussions of songs (listening control).	30	1/week	Standard care	84 (60 F) Singing = 27 Listening = 29 Control = 28	AD = 40 Vascular = 19 Mixed = 11 Other = 14	Clinical dementia rating mean = 1.2	Neuropsychological tests (BNT); verbal subtests of MMSE, WAIS-III, CERAD, WAB.	Baseline, immediately post intervention (3 months) and 6 months post intervention (9 months).	Music intervention groups, particularly singing, showed greater number of recalled persons from their childhood compared to control group ($p = .036$).
Dassa and Amir (2014)	MT: Therapist sang to group (with guitar) and invited patients to sing, 4 songs twice/session.	45	2/week	N/A	6 (4 F)	AD	MMSE (range) = 7–20	Questions asked about lyrics at end of song to stimulate conversation. Analysis of spoken and sung material and song features.	N/A (content analysis of each session).	Spontaneous speech in conversation increased after group singing.

Interventions marked with ^a within-subject design, ^b between-subject design.

MMSE: Mini mental state examination; WAB: Western Aphasia Battery; BNT: Boston Naming Test; WAIS-III: Wechsler Adult Intelligence Scale; CERAD: Consortium to Establish a Registry for Alzheimer's disease.



dementia has raised significant concerns about the quality of the existing evidence (Van der Steen et al., 2017), and questions have also been raised about the specificity of the effect of music (e.g., Narme et al., 2014). Moreover, these large-scale studies have not used personalised or self-preferred music, which is known to have the most beneficial effects for people with dementia, including reducing agitation (Gerdner, 2012), stimulating autobiographical memories (Cuddy, Sikka, Silveira, Bai, & Vanstone, 2017), and reducing depression and maintaining various cognitive functions (Särkämö et al., 2016). The RCT of Särkämö et al. (2016) demonstrated the efficacy of using caregiver implemented music activities (singing and music listening that incorporated personally preferred music) on mood and cognition. There is a need for further research of the “real world” uses of music, outside of an experimental or formal therapeutic setting. This case study starts to address this need by examining how a husband and carer of a woman with severe aphasia and a comorbid delusion used music in a personalised and informal way in the home setting to address these symptoms of dementia.

1.1. Misidentification syndrome in dementia

Delusions, in particular misidentification syndrome, can be a comorbid symptom in various types of dementia. There has been scarce study of the use of music in the treatment of such delusions in dementia. The subject of this case study, TC, a woman with aphasia in the context of severe dementia, came to the attention of the first author when TC’s husband contacted her and discussed his experience of using music, specifically singing a familiar and significant song, to overcome TC’s misidentification delusion. Misidentification of familiar people occurs in psychiatric disorders such as schizophrenia, and in people with neurological conditions including dementia, most commonly AD or Dementia with Lewy Bodies (DLB, Harciarek & Kertesz, 2008).

In one form of delusional misidentification syndrome, called Capgras delusion, patients form the belief that a significant other, typically a spouse, has been replaced by an identical imposter. The symptoms exhibited by TC are broadly consistent with this classification. Josephs (2007) reported that 81% of people with Capgras delusion had a neurodegenerative disease, most commonly DLB, and Harwood, Barker, Ownby, and Duara (1999) found that the delusion was present in 10% of community dwelling people with AD. In some cases, this delusion can be associated with violent behaviour (Cipriani et al., 2013; Kaufman, Newman, & Dawood, 2014). The standard treatment for Capgras delusion is anti-psychotic medication. We are unaware of any published reports of the use of music in treating this specific delusion, but note that Raglio et al. (2008) reported decreased delusions (as measured by the Neuropsychiatry Inventory, without any details on types of delusions) in 30 people with dementia who participated in 30 music therapy sessions over 16 weeks compared with a control group who did educational support or entertainment activities. There was also a recent anecdotal report specific to the use of singing for misidentification delusion in a woman with dementia. In his welcome speech at the Neuroscience and Music VI conference in Boston (2017), the Chief Executive Officer of Harvard Medical School stated that his mother, who has severe dementia, “thought I was an imposter, and only recognises me when I sing to her”.

We had two aims of this case study; (1) to explore and compare TC’s expressive language and music skills through qualitative interviews with her husband, behavioural

Table 2. Retrospective timeline of TC's expressive language and music skills based on interviews with her husband.

Year	Ability to speak	Ability to sing
2010	Intact	Intact
2011 (AD diagnosis)	No change	No change
2012	Hesitant in her speech, "cautious of what she said", word finding difficulties	No change
2013	Not talking as much, "she became quieter"	Reduced volume but same frequency of singing. Joined weekly singing group for people with dementia and their carers.
2014	Hesitant, hard to understand.	As above. Still singing at home and in weekly singing group.
2015	Not saying much. Only "Bernie", "Dad", "da da", and an occasional phrase such as "I love you". Husband stated "But it's all in there, I felt she could still understand"	As above, but unable to read lyrics during singing group. Singing lyrics to songs from memory.
2016	Hard to converse with her, "not a sensible conversation"	Going out the front of singing group and still singing. One month before Christmas only humming.
2017	As above. She can say single words such as "Bernie", "Dad", "yes" or "no", but is inconsistent in her responses. On rare occasions she utters a sentence, completely "out of the blue". "I need to interpret and guess what she is saying. It's hard to do now. She takes in a lot but getting it out is not easy". She makes constant oral movements, gnashing her teeth and poking tongue out repeatedly.	After a few weeks break over Christmas, she no longer sings or hums when attending singing group. Often sleeps while attending.

observations and formal assessment, and (2) to document how TC's husband used music in caregiving, in particular in overcoming her misidentification delusion.

2. Methods

2.1. Participant

TC was a 77 year old woman who was diagnosed with AD by a geriatrician in 2011, 6 years before the current study. She resided in Australia and was monolingual (English only). Her husband commented that they had the referral for the geriatrician from their

Table 3. TC's scores on the *Music Engagement Questionnaire* (MusEQ informant version completed by her husband) compared with aged matched healthy controls.

MusEQ subscales ^a	TC's score	Percentile ^b
Daily	2.43	35–40
Emotion	4.19	80–85
Perform	1.99	60
Consume	2.40	20–25
Respond	2.95	50–55
Prefer	4.07	45–50
Total score	3.00	50–55

^a Vanstone et al. (2016)

^b Mean percentiles for healthy people aged 12–84 years obtained from Vanstone, personal communication.

General Practitioner for 12 months before making an appointment. In the 2 years prior to her diagnosis she had demonstrated cognitive changes including getting lost, repeating herself and misplacing objects, particularly when in unfamiliar environments such as during holidays. There was one occasion after a general anaesthetic for a knee operation when she briefly failed to recognise herself in a mirror.

At the time of her diagnosis, her Mini Mental State Examination (MMSE) score was 18/30. A CT brain scan showed small vessel ischaemia particularly in the periventricular region on the left side anteriorly. This would suggest a possible vascular component to her dementia, but as noted above she was diagnosed with probable AD by the geriatrician. She saw the geriatrician only once and did not undergo any other formal assessments.

Her misidentification delusion occurred intermittently in the year after her diagnosis for 6–12 months. It would occur suddenly and out of the blue. For example, if she went into another room she would ask her husband “who are you?” on her return and order him out of the house. These episodes typically lasted 1–3 h. Her husband would go out and sit in his car and wait. On one occasion, she said, “don’t go and sit in the car, that’s B’s (husband’s) car”.

At the time of the current study, TC and her husband had been married for 57 years and he was caring for her in their home. She had a carer 2 days a week to assist with showering and walking, and attended a dementia day care centre 2 days a week. She presented as somewhat agitated and paced around the room moving items (picture frames and other household items) and occasionally touched her husband’s arms or face. She made continuous oral movements (lip smacking and poking her tongue out). She was severely aphasic with impaired expressive and receptive language. Her speech was characterised primarily by unintelligible sounds with an occasional word (e.g., her husband’s name), and she did not appear to comprehend and failed to respond to any questions. Over the last 5 years they attended a weekly singing group for people with dementia and their carers. TC had no formal music training, but always enjoyed singing. Her husband stated that as a little girl, she was the “entertainer” when visitors came over. She would recite poems and sing. Her father once said “if TC isn’t singing there is something wrong”.

2.2. Tasks

2.2.1. Interview with husband regarding TC’s decline in expressive language versus music skills over time

Several interviews were conducted with TC’s husband to gain a retrospective view of the progressive decline in her expressive music and language skills, with a focus on her singing ability and expressive language skills.

2.2.2. Formal assessment of music engagement and language skills

TC’s music engagement was assessed using the informant version (completed by husband) of the *Music Engagement Questionnaire* (MusEQ, Vanstone, Wolf, Poon, & Cuddy, 2016) which was developed for people with dementia. This 35 item questionnaire measures engagement with music in daily life and has self and informant versions. It contains six subscales; (1) “Daily”, which addresses the role of music in routine daily life, (2) “Emotion”, which concerns the emotion and mood regulatory aspects of musical experience, (3)

“Perform”, which involves music in social contexts such as musical performance and identity, (4) “Consume”, or consumer musical choices, (5) “Response”, or responses made in synchrony to music, and (6) “Prefer”, or the extent a person shows preferences or dislikes to certain music styles. Formal assessment of TC’s language skills was attempted by the first author using the *Sydney Language Battery* (Savage et al., 2013).

2.2.3. Purposefully developed questionnaire regarding TC’s husband’s use of music in caregiving

We designed a questionnaire (see [Appendix 1](#)) to explore how often TC’s husband used music, including listening, singing and dancing, in his caregiving.

2.2.4. Behavioural observation during different language and music conditions

TC’s behaviour and verbal communication was observed at her home during four different conditions, presented by her husband; (1) reading a newspaper article, (2) reading familiar song lyrics, (3) singing familiar song lyrics, and (4) listening to the original version of the familiar song. The familiar songs were identified by husband. Each condition was done once for approximately 3 min. TC’s behaviour was observed and filmed for later review of verbal communication by author AB.

3. Results

3.1. TC’s expressive language versus music skills

[Table 2](#) shows a retrospective timeline of qualitative aspects of TC’s expressive music and language skills (specifically singing and language production) based on interviews with her husband. This shows that her singing ability persisted for at least 4 years from the onset of her expressive language difficulties, and only ceased in the 6 months preceding the current study, compared with her expressive language skills which became limited to only a few words 2 years ago.

3.2. Formal assessment of language and music engagement

TC was unable to complete any items of the formal language tasks. She only briefly glanced at the stimuli and continued staring at the examiner’s (AB’s) face and made unintelligible sounds and continuous oral movements. She did not appear to comprehend the task instructions and failed to respond. In contrast, her music engagement skills were found to be relatively preserved, as shown by her scores on the MusEQ (informant version), as displayed in [Table 3](#). All her subdomain scores and her overall score were in the average range according to percentiles of healthy controls. She showed a relative strength on the “emotion” subscale. This shows that her music engagement skills remained strikingly preserved, in contrast with her devastating language impairment.

3.3. Use of music in caregiving

Results from the purposefully developed questionnaire completed by TC’s husband revealed that he sang to her and they listened to music daily, and danced together a

few times a week. He said, "The first thing I do in the morning is put music on". This was a new routine since the onset of her dementia.

In regard to his reasons for singing to her, he responded yes to all reasons provided, except to aid with showering or toileting. He commented, "singing was a way of calming and caring for our three children which TC did all the time". His specific reasons for dancing with her were to "help me feel connected to her", "because she and I enjoy it", and "to remember a special time or event we shared". During dancing, they had a physical closeness separate from standard caring activities (toileting and washing), and this appeared to affirm their relationship and enabled him to reconnect with her and reminisce about their past shared experiences.

He stated that he used music at certain times of the day to modulate her mood or physical activity. For example, music "gets her started in the morning". He turned the volume up to upbeat pop music such as songs by Johnny Farnham. Conversely, when she was tired, music helped her settle and sleep. He turned the volume down and chose soothing music such as John Denver or Ronin Keating. The use of music also benefitted him. He stated, "I use music for TC, but it's also for me, it gets me up and going. I enjoy singing and going to the singing group too". Furthermore, he commented, "well, TC is not talking much. It's virtually a conversation, it's someone speaking/singing. That's what I miss most, the ability to talk with her".

3.3.1. Using music to overcome TC's misidentification delusion

Her husband stated that he had mentioned the episodes of misidentification to a geriatrician, who suggested singing a familiar and significant song to her. He chose "Unchained Melody", as it was a song that had played on the evening when they first met. It marked the start of their relationship as it had been the last song of the evening and they had enjoyed dancing to it. He started singing this song to her multiple times a day, and within a couple of weeks, "everything changed. It worked quickly. She came back. She stopped sending me away, and became my shadow".

3.4. Behavioural observation during different language and music conditions

There was no observable change (informal behavioural observations) in TC's behaviour or expressive language between any of the four conditions. She paced around the room and moved items around on the dining table. There was also no change in her expressive language. She made continuous oral movements and unintelligible sounds. She did not sing any of the lyrics or express any words in any condition. Her husband enjoyed singing along to the original songs, and during "Unchained Melody", he asked her to dance with him. She appeared to become more settled and calmer in her presentation (ceased pacing and moving objects around, ceased oral movements) while dancing.

4. Discussion

This qualitative and retrospective case study is the first longitudinal observation documenting dissociation between spoken and sung speech in the context of dementia. TC, a 77 year old who was diagnosed with AD 6 years prior to participating in the current

study, had preserved singing ability for at least 4 years after the onset of her expressive language difficulties, according to her husband and carer. Even when she became severely aphasic and was only able to say a few words and a very occasional phrase, she continued to sing familiar song lyrics during group singing sessions for 2 years. Furthermore, her music engagement skills, including her emotional responsiveness to music and ability to express musical preferences (as measured the MusEQ, an informant rated dementia specific questionnaire completed by her husband) remained in keeping with healthy people. These findings highlight the striking dissociation between expressive language and music functions in people with dementia, and suggest that music (specifically singing and music engagement skills) remains relatively resistant to the pathology of dementia. While the dissociation between expressive language and music skills was explicitly observed and incontrovertible, this case also implies a dissociation between receptive skills of music and language. Nevertheless, TC's non-responsiveness makes it difficult to draw strong conclusions about the relative preservation of receptive skills of music compared with language comprehension.

Despite anecdotal reports of non-responsive people with severe dementia who have lost verbal communication skills but retain the ability to sing familiar songs, to the best of our knowledge this is the first formal documentation of this phenomenon. Our case suggests that singing ability can remain spared for several years after language decline, until the very severe stage, while music engagement, in particular emotional responsiveness to music, can persist even during the very severe stage.

This case study contributes to previous literature documenting the relative preservation of music cognition skills in the face of dementia, both in musicians and non-musicians (for a review see Baird & Samson, 2015). Although TC had no formal music training, she always loved singing and engaged in this activity daily since childhood. In keeping with our previous observation of spared learning and recall of novel music by singing in a woman with severe dementia who loved singing but had no formal music training (Baird, Umbach, & Thompson, 2017), TC's love of music may have predisposed her to exhibit this spared ability. It is unknown if previous (pre-dementia onset) and frequent engagement in singing is a necessary requirement for the later sparing of this ability in the face of dementia, but it is likely to play a role. Furthermore, it may have underpinned her responsiveness to singing in resolving her misidentification delusion.

The relative preservation of singing in the context of impaired expressive language abilities may reflect differences in the neural processing and correlates of these two skills. Specifically, familiar song lyrics are typically well rehearsed formulaic sayings, whereas expressive language requires the construction of novel utterances to communicate an "on-the-spot" communicative intention. Both lesion and neuroimaging studies have provided insights into this issue. Based on their extensive clinical studies of people with acquired brain injury and neurological disorders including AD and Parkinson's disease, Van Lancker Sidtis and colleagues have proposed that formulaic language is mediated by right hemisphere and subcortical brain regions (Van Lancker Sidtis, Choi, Alken, & Sidtis, 2015). Their model predicts that normal production of formulaic expressions is associated with intact basal ganglia, whereas storage and retrieval of formulaic expressions are mediated by the cortical right hemisphere (Van Lancker Sidtis et al., 2015). Given the relative integrity of subcortical brain regions in AD, their model predicts spared production of formulaic expressions in this population, and studies have

supported this prediction (Bridges & Van Lancker Sidtis, 2013; Van Lancker Sidtis et al., 2015). TC's CT brain scan revealed small vessel ischaemia particularly in the left anterior region, and no reported anomalies in the contralateral regions, suggesting relative sparing of her right frontal region. Furthermore, as subcortical structures including the basal ganglia remain relatively spared of AD pathology, this brain region may have also played a role in mediating her preserved singing relative to expressive language ability.

Neuroimaging studies of healthy people also provide insights into the neural correlates underlying singing and speaking. For example, in their fMRI study, Ozdemir, Norton, and Schlaug (2006) found a large shared network for singing and speaking, including inferior pre- and post-central gyrus, superior temporal gyrus (STG), and superior temporal sulcus (STS) bilaterally. Additional regions activated during singing included the mid-portions of the STG (more strongly on the right than left) and the most inferior and middle portions of the primary sensorimotor cortex. Similarly, in a PET study that compared singing or speaking lyrics to a familiar song, singing produced relative increases in activity in right temporal and frontal regions, including STS, STG, and medial and dorsolateral prefrontal cortices (Jeffries, Fritz, & Braun, 2003). As described above, the integrity of TC's right anterior and temporal regions may partly account for her spared singing ability. Future neuroimaging studies could explore the neural correlates of singing and speaking in dementia populations, and the effects of music-based treatments on aphasia in the context of dementia.

Behavioural case studies have investigated the dissociation between speaking and singing in people with non-fluent aphasia due to acquired brain injury. Cases vary in their lesion location and methodology used. For example, singing compared with speaking familiar song lyrics resulted in an increased number of words in a patient with an extensive left hemisphere lesion (Straube, Schulz, Geipel, Mentzel, & Miltner, 2008), but this difference was not observed in a patient with non-fluent aphasia due to right hemisphere stroke (Hébert, Racette, Gagnon, & Peretz, 2003). Rather, in the patient with the right hemisphere lesion, the mean number of notes produced was higher than the words produced, indicating a dissociation between musical and verbal productions. As discussed in the introduction, there are scarce empirical studies examining the issue of singing versus speaking or the facilitation of speaking through singing in people with aphasia due to dementia. Although this case study provides some qualitative insights, this current gap in the literature needs to be addressed with formal quantitative assessments. Conclusions drawn from the literature on treatments for stroke (e.g., the beneficial effects of MIT on post stroke aphasia) cannot necessarily be applied to dementia populations given differences in pathology (focal versus more diffuse) and the forms of aphasia associated with each condition.

Music is often a social activity, and certain benefits observed in response to music may be partly attributable to the social dimension of music. Studies of group singing for people with dementia and their carers have highlighted that carers benefit as much as the affected individual. For example, group singing activities have social benefits such as improved relationships, feelings of inclusion, and support for carers (Osman, Tischler, & Schneider, 2016; Unadkat, Camic, & Vella-Burrows, 2017). This case study contributes to this literature by considering how couples can use music for therapeutic purposes, with a focus on aphasia in dementia. TC's husband described how he used music listening daily to adjust TC's mood or behaviour, but also for himself. Given TC's severe aphasia

and lack of verbal communication skills, music replaced their conversation. Her lack of verbal communication skills is what he missed the most, and his constant playing of music was a means of filling the silence. He also danced with TC, and this activity provided a chance for physical affection outside of the standard care activities (toileting and showering). It reaffirmed their relationship and enabled him to remember previous shared experiences. Of note, the only observable change in TC when observed in four different conditions (namely her husband reading a newspaper article, reading familiar song lyrics, singing familiar song lyrics, or listening to the original version of the familiar song) was that she became calmer (ceased oral movements and pacing) when dancing with her husband to the original familiar song "Unchained Melody". His spontaneous invitation to dance to this song means that it is not possible to disentangle the impact of the music from the physical contact with her husband during this condition. Nonetheless, these observations demonstrate his use of music as a positive tool for both of them. In the absence of verbal communication, music provided a form of non-verbal communication that supports their relationship and interpersonal identity. We have recently proposed that music is uniquely equipped to engage multiple aspects of the self in people with dementia (Baird & Thompson, 2018). In this case, music appeared to be particularly effective at enhancing TC's "interpersonal self", especially in the context of her relationship with her husband.

The most striking use of music in his caregiving was his singing of a familiar and significant song as a means of overcoming her misidentification delusion. Misidentification delusions commonly occur in AD and other types of dementia, such as DLB (Harciarek & Kertesz, 2008). Therefore, this observation has both clinical and scientific significance as a non-pharmacological treatment for this symptom of dementia. Singing is a universal ability and every carer can try it. It does not have the potential side effects of pharmacological treatments. Our observation demonstrates the power of a familiar human voice and melody for effective recognition of a significant other, over and above visual cues. Using music, in particular familiar and significant songs, is a uniquely effective way of promoting recognition of a close relative, and correspondingly, maintaining interpersonal relationships. Further research is needed to investigate the effectiveness of different cues (visual, auditory, and olfactory) to aid recognition of family members by people with dementia both in the context of misidentification delusions and also longitudinally during the progression of cognitive decline.

A limitation of this case study is the reliance on TC's husband's self-report. Moreover, TC died during the write up of this case study and we were unable to obtain any further corroborative history from other relatives at this emotionally distressing time. Nevertheless, her husband had read the manuscript and agreed that it accurately represented his experience and observations of his wife. Given the retrospective and observational nature of this case study it is difficult to dissociate the impact of music on TC's mood, non-verbal communication and behaviour. It is likely that positive effects on all three of these functions contributed to the resolution of her misidentification delusion. Furthermore, we cannot determine whether or not the observed benefits were due to the musical stimulation alone or the social and physical interaction with a familiar person (in this case her husband), or the co-occurrence of music with a familiar person. Future studies could attempt to disentangle the relative contribution of these factors by comparing the effects of music in the presence or absence of a familiar person.

Experimental paradigms that utilise recorded auditory stimuli (for example familiar and unfamiliar voices and music) that could be presented via headphones to individuals alone, or in the presence of familiar caregivers, could help to clarify the effects of each of these factors. In addition, the use of formal objective measures of emotional, behavioural and physiological reactions (such as heart rate and skin conductance) would be informative, particularly in those with severe aphasia. Formal assessment of language and music functions (both music cognition skills and music engagement) using standardised measures that are dementia specific where possible (such as the *Sydney Language Battery*, Savage et al., 2013; for those with PPA; or the *Western Aphasia Battery-Revised*, Kertesz, 2007; the *Montreal Battery for the Evaluation of Amusia* (Peretz, Champod & Hyde, 2003) and the MusEQ, Vanstone et al., 2016) would also be beneficial to determine the types of individuals who benefit most from music interventions and to enable longitudinal quantitative monitoring of changes.

In conclusion, this case study characterises the relative preservation of music (specifically singing ability) compared with language functions over time in the context of aphasia in dementia. It also illustrates the remarkable capacity of music, in particular singing of a familiar and significant song, to overcome misidentification delusion in dementia. In this way, music can replace language as a means of recognition of a significant other. It also demonstrates how music can be used by a caregiver in an informal and personalised manner to maintain interpersonal identity and social connectedness. Given our ageing population and the corresponding increasing incidence of dementia with no cure in sight, the promising potential of the use of music as an effective non-pharmacological treatment for various symptoms of dementia warrants further research.

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Appendix 1. Purposefully developed questionnaire regarding use of music during care activities

Please circle one number for each statement below:

- 0 = Never
- 1 = Rarely
- 2 = Once a month
- 3 = Once a week
- 4 = A few times a week
- 5 = Every day

How often do you and TC listen to music together? 0 1 2 3 4 5

How often do you and TC dance to music together? 0 1 2 3 4 5

How often do you sing to TC? 0 1 2 3 4 5

For the following questions please circle YES or NO and also write your own reasons if there are any that are not listed:

(1) **Do you sing to TC for a specific reason? For example:**

- To calm her down if she is agitated YES NO
- To help me feel connected to her YES NO
- To communicate something to her YES NO
- Because I enjoy it YES NO
- Because she enjoys it YES NO
- To remember a special time or event that we shared YES NO
- To help me do care activities such as showering or toileting with her YES NO
- Any other reasons (please write here).....

(1) **Do you dance with TC for a specific reason? For example:**

- To calm her down if she is agitated YES NO
- To help me feel connected to her YES NO
- To communicate something to her YES NO
- Because I enjoy it YES NO
- Because she enjoys it YES NO
- To remember a special time or event that we shared YES NO
- Any other reasons (please write here).....

Please describe any other ways in which you use music with TC and why you think it is helpful for you and/or her.....

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