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Cognitive-load of activities for Māori and non-Māori: a New Zealand consensus

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Abstract

Introduction: *To estimate the cognitive-load of self-reported physical and cognitive activities by New Zealand's (NZ) Māori (indigenous population) and non-Māori from the Life and Living in Advanced Age-Cohort Study New Zealand (LiLACS NZ).* ***Methods****: Three-round panel Delphi exercise in NZ involving six panellists across an expert rater group and a peer-rater a group of Māori and non-Māori respectively, via web-based and face-to-face discussion.*

Results: *In Round i (pre-Delphi exercise) the investigator group, gathered and categorised data from LiLACS NZ and developed a 9-point Likert-scale to rate the cognitive-load. Round ii panellists each rated the cognitive-load of each activity. If*

a priori specified criteria were not met, then round iii involved a face-to-face meeting to discuss and re-rate activities on which consensus was lacking. ***Conclusions****: Māori reached consensus in round ii while non-Māori did so in round iii. Panellists provided a formal consensus-based cognitive-load rating for 181 activities separately for Māori and non-Māori.*

Keywords: *Delphi technique, physical activity, ageing, cognitive activity*

Introduction

Modifiable risk factors, such as participation in physical activities, may influence and be modulated by the onset and progression of cognitive decline (Livingston et al., 2017). Physical activity positively affects cognition (Colcombe & Kramer, 2003; Kramer, Erickson, & Colcombe, 2006), and its cognitive-load could help to postpone dementia. However, physical activity is not typically perceived as having a cognitive-load component even though engagement requires activating the motor and sensory cognitive domains (Raichlen & Alexander, 2017). Different types of physical activity may also require inputs from other cognitive domains, such as attentional, executive, and/or visuospatial processes. Thus, physical activity requires both physical and cognitive function.

Animal studies show that having physical and cognitive components of an activity delivered simultaneously, such as complex and novel physical activity, increases

cognitive benefit and neuroplasticity (Kempermann et al., 2010). Thus, determining the cognitive-load of a range of activities may provide insight into mechanisms underlying potential benefits for cognitive function, and also enable examination of how, and if, the extent of any benefits are associated with differing levels of cognitive demand in physical activities. This in turn may facilitate the design of interventions and preventive strategies that could mitigate further cognitive impairment whilst advantaging individuals, their family (whānau) and the community. Interventions that delay the onset or progression of dementia by one year, compared to no change in onset, could result in almost 9.2 million fewer cases by 2050 (Brookmeyer, Johnson, Ziegler-Graham, & Arrighi, 2007).

The cognitive-load of both physical activity and cognitive activity is a subjective, multidimensional construct depicting the cognitive capacity required to engage in an activity (Ayres, 2006; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Paas & Van Merriënboer, 1994). A measure of cognitive-load can facilitate understanding of an activity's cognitive demand. The degree of cognitive-load may vary with the type of activity. Several studies have reported different types of activities and the estimated degree of cognitive-load required for engagement (Karp et al., 2006; Salthouse, Berish, & Miles, 2002; Wilson et al., 1999). Yet, the cognitive-load of many activities remains unknown (Salthouse et al., 2002). Most of the current

knowledge about the cognitive-load of activities is from Sweden (Karp et al., 2006) and the United States' (Salthouse et al., 2002; Wilson et al., 1999), although the number of studies to date is small. In combination with the unknown effects of differences in New Zealand's (NZ) culture and lifestyle, this situation indicates potential benefits of assessing the cognitive-load of activities in a NZ context. There could also be differences between NZ Māori (indigenous) and non-Māori with regard to the cognitive-load of specific activities when Western definitions and measures of cognition and/or activities do not adequately reflect Māori constructs, perceptions, and worldviews. More specifically, the cognitive complexity of activities for Māori may well differ from that for non-Māori for reasons including cultural demands.

Māori cultural concepts are distinct, with lessons from history passed down from generation to generation through oral pūrākau (myths/legends/stories) and via artistic traditions like whakairo (carving) of wood, greenstone, and bone. Cultural ceremonial practices involving oral traditions necessitate detailed memory of ancestry and interrelationships between tribal groupings. For example, distinctive cognitive-loads may arise from the physical demands of a whānau approach to cultivation, hunting, gathering, and preparation of kai (food) (Wham, Maxted, Dyall, Teh, & Kerse, 2012), and from assembling at marae (social and ceremonial

meeting grounds). The meetings at marae foster multi-generational engagement in diverse cultural activities (de Bruin & Read, 2018) such as kapa haka (dance), poi (a light ball on string swung or twirled rhythmically), raranga (weaving), and singing in te reo (Māori language). Thus, Māori have actively integrated their traditions and culture into their daily activities in ways that may help to explain why Māori, compared with non-Māori, tend to engage less in formal exercise. The cultural activities in which Māori participate may impose different cognitive-loads to those associated with activities that sound nominally similar to those in which non-Māori participate. In addition, effects of colonisation including relative social and economic disadvantage continue to affect Māori adversely. These impacts limit equality of opportunity for Māori, and are likely reflected in unequal health outcomes including Māori having a seven year deficit in life expectancy (Statistics New Zealand, 2017), and greater risk of dementia (Kerse et al., 2015), compared with non-Māori. Given the sparse research on the cognitive-load of activities, with no studies examining those reported by Māori and non-Māori, and its potential application to future studies, this study undertook a Delphi exercise to establish formal consensus on the cognitive-load of self-reported activities of Māori and non-Māori octogenarians.

Methods

A Delphi flexible study design facilitates formal consensus-building by groups. Ours comprised two groups of panellists who rated the cognitive-load of a diverse range of activities.

Study design

Implementation of a three-round Delphi exercise was modified by provision to bring panellists face–to–face in the third round. *A priori*, a limit of three rounds was selected (Mullen, 2003) because formal consensus is typically achieved within three rounds and because we wanted to reduce attrition rates from participant burden. Figure 1 outlines the use of the three rounds to collect and analyse ethnic specific cognitive-load data separately for Māori and non-Māori (Bishop, 1999). The study is reported according to Conducting and REporting DElphi Studies (CREDES) (Jünger, Payne, Brine, Radbruch, & Brearley, 2017). Data were part of a 6-year, multi-centred, population-based, prospective, longitudinal cohort study of Māori and non-Māori octogenarians from the, *te puawaitanga o nga tapuwai kia ora tonu, Life and Living in Advanced Age; a Cohort Study in New Zealand* (LiLACS NZ). Ethics approval was obtained from the Northern Health and Disability Ethics committee (NXT/09/09/088).

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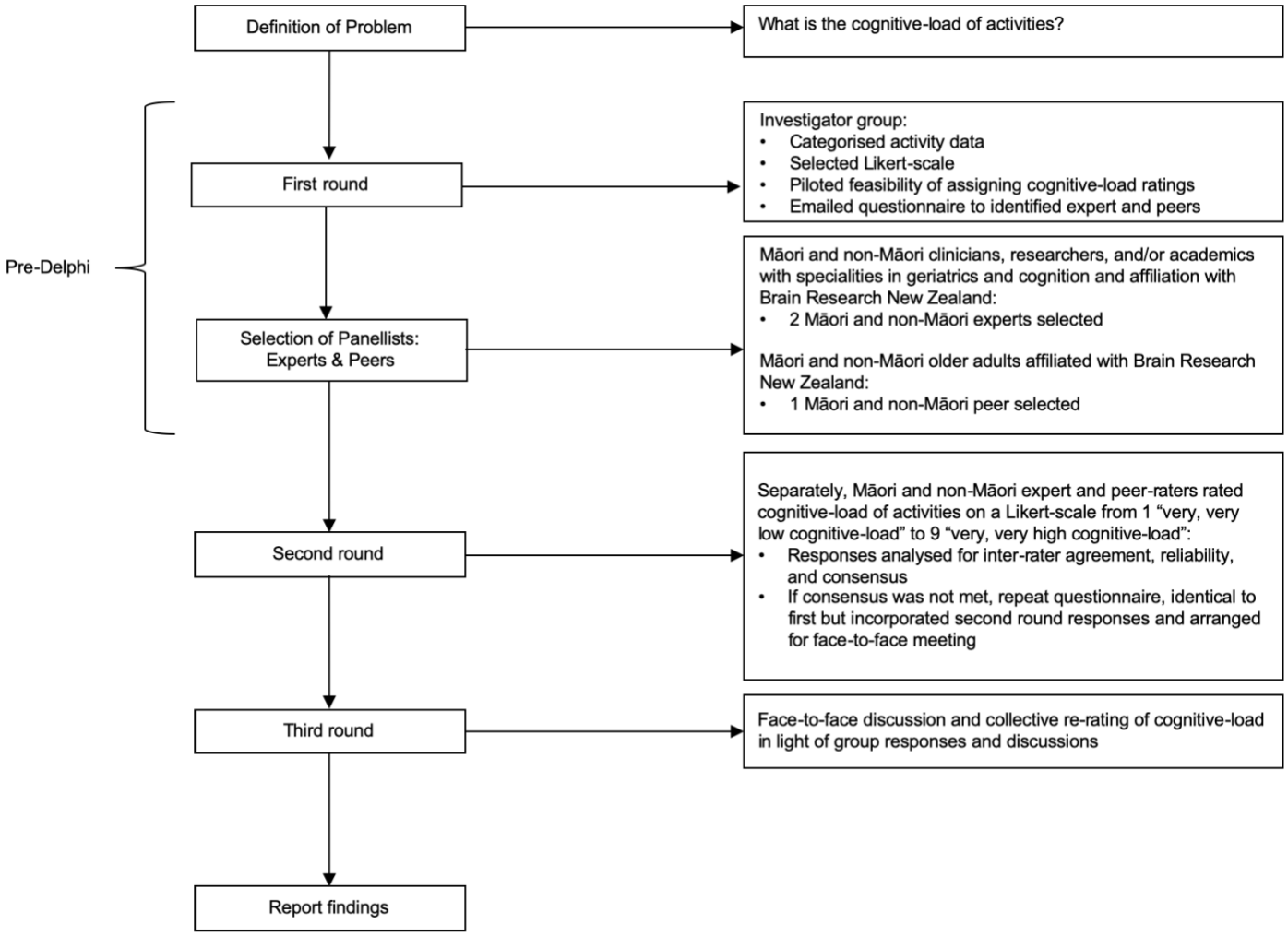

Figure 1 Study design

Rounds

Round i (pre-Delphi exercise)

Investigator group

The investigator group consisted of NK, LT, and KZ who are affiliated with Brain Research NZ, a Centre of Research Excellence and SB. NK and LT have extensive experience from general practice and psychology respectively, in study of cognitive function, collectively with at least 50 years of research and clinical experience. KZ has academic foundations in kinesiology, psychology, and gerontology. SB, is a health researcher with international experience in formal consensus-building methods.

As this study relies on secondary data, identifying and categorising LiLACS NZ data was the responsibility of the investigator group, as were selecting the Likert-scale, determining the *a priori* specified criteria, and piloting the Delphi exercise.

LiLACS NZ data

In 2010, octogenarian Māori and non-Māori were enrolled in LiLACS NZ, to determine predictors of successful advanced ageing. LiLACS NZ's protocol (Hayman et al., 2012), study recruitment, and representativeness (Dyall et al., 2013) have been described in detail. Kaupapa Māori methodology (Māori approaches to research) was applied to engage and recruit as complete a sample of eligible Māori as possible (Hayman et al., 2012).

In brief, annually participants either completed the full or core assessment. Data from participants completing the full assessment were included in this study. We utilised baseline data to account for the complex cognitive process required to self-recall activities (Baranowski, 1988) in which one had participated over the previous seven days. The data derived from LiLACS NZ related to participants' spontaneous self-reported participation in response to a question with six sub-questions in the Physical Activity Scale for the Elderly (Washburn, Smith, Jette, & Janney, 1993). This question was selected because current activity and current cognitive function are strongly associated, more so than with past activity (Wilson et al., 2005). The trained assessor orally asked the following sub-questions prefaced with the statement "Over the past 7 days, how often did you….?"

- Participate in sitting activities, such as reading, watching television, or doing hand crafts?
- Take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog etc.?
- Engage in light sport or recreational activities, such as light gardening, bowling, golf with a cart, shuffleboard, fishing from a boat or pier, or similar activities?
- Engage in moderate sport and recreational activities, such as moderate gardening, double tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball, or other similar activities?
- Engage in strenuous sport and recreational activities, such as heavy gardening, jogging, swimming, cycling, singles tennis, aerobic dance, skiing, or other similar activities?
- Do any exercise to increase muscle strength and endurance, such as lifting weights or push-ups etc.?

Each of the above sub-question was followed by… “What were these activities…?”, which the trained assessor recorded verbatim.

Participant responses were explored to ensure they met the study aim. KZ and NK pragmatically classified activities into either physical or cognitive, according to their dominant characteristic. To examine potential benefits of activities regardless of their composition, no activities from LiLACS NZ data were removed. Activities with predominately physical effort were categorised as physical while activities with predominantly cognitive effort were categorised as cognitive. Group or solitary participation did not impact the categorisation. Classifications were compared, with any disagreement resolved through discussion. The classifications were validated against the opinion of a sample of healthy older Māori and non-Māori, resulting in 95 physical activities and 86 cognitive activities. The cognitive-load required for each activity was estimated on a 9-point Likert-scale, which utilises Paas, 1992 as a template (Table 1). The investigator group piloted assigning the cognitive-load of the activities extracted from LiLACS NZ (Supplemental 1).

Table 1 Cognitive-load 9-point Likert-scale

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Very, Very low Cognitive-load	Very low Cognitive-load	Low Cognitive-load	Rather low Cognitive-load	Neither low nor high Cognitive-load	Rather high Cognitive-load	High Cognitive-load	Very high Cognitive-load	Very, very high Cognitive-load

Round ii

Suitable panellists were identified as experts in psychology, psychiatry, and/or geriatrics, where an expert is defined as persons who are informed individuals, specialists in the field, or someone who has knowledge about a specific subject (Keeney, Hasson, & McKenna, 2001). An email invitation was sent (Jones & Hunter, 1995) to potential members of the expert and peer-rater groups (Karp et al., 2006; Wilson et al., 1999). It included details of the study, the nature of their participation and how their involvement indicated consent to participate voluntarily and they could withdraw at any point. Also included was the Qualtrics™ web-link to the questionnaire.

The purpose of round ii was to have panellists apply the Likert-scale to rate the cognitive-load that they estimated was required for engagement in each activity. After the completion of round ii, the strength and relationships of pairwise comparisons between raters was evaluated, as was the inter-rater reliability and inter-rater agreement. If the *a priori*-specified criterion of inter-rater agreement, a Kendall coefficient of concordance (W) > 0.61, was met in the analysis of the expert-rater plus peer-rater and investigator group, then the median ratings of cognitive-load for each activity were utilised. However, if the *a priori*-specified criterion was not met, round iii was initiated.

Round iii

In this round, the activities that had expert-rater, peer-rater, and the investigator group's cognitive-load ratings in a single tertile were deemed to have achieved consensus. The activities not meeting this criterion became the focus during this round.

No ratings were discarded between the rounds, resulting in no loss of information (Fitch, Bernstein, Aguilar, Burnand, & LaCalle, 2001). The cognitive-load ratings acquired from round ii were anonymised and medians for each activity were provided to facilitate discussions and potential re-rating. The face-to-face meeting provided the platform to determine whether the differences between raters' ratings were due to a true disagreement or a misunderstanding/misinterpretation (Fitch et al., 2001). Following the discussion of each activity's cognitive-load, a "round-robin" style of re-rating was used by the expert-raters, peer-rater, and investigator group on the Likert-scale utilised in round ii.

Statistical Analysis

To adjust for differences in distributions of ratings between panellists, we created study-specific tertiles to evaluate agreement and reliability for the cognitive-load ratings of activities. Quantitative values were expressed as medians.

Following round ii, three statistical analyses were completed: 1) Kendall's W determined inter-rater agreement in the analysis of the expert-rater plus peer-rater and investigator group, which was interpreted as: 0–0.019 very weak, 0.20–0.39 weak, 0.4–0.59 moderate, 0.6–0.79 strong, and 0.8–1 very strong (Evans, 1996); 2) intraclass correlation coefficients (ICC), using a two-way mixed-effect model, explored the inter-rater reliability for the total sample of activities and were interpreted as: < 0.40 poor, 0.4–0.59 fair, 0.6–0.74 good, and 0.75–1 excellent (Cicchetti, 1994); and 3) Spearman rank-order correlation coefficients were applied to indicate the strength and direction of relationships between pairs of raters for the total sample of activities. All analyses were completed using SAS, version 9.3 (SAS Institute Inc. Cary, NC) and Statistical Package for the Social Science, version 25.0. Statistical significance was defined as $p < 0.05$.

Results

All invited raters independently rated the cognitive-load during the consecutive rounds, where necessary. The background of the panellists is described in Table 2.

Table 2 Details of panellists

	Māori n (%)	Non-Māori n (%)
Overall	3 (100)	3 (100)
Clinical psychologist	1 (33)	1 (33)
Physician in geriatrics	1 (33)	-
Psychiatrist in geriatrics	-	1 (33)
Older adult	1 (33)	1 (33)
Affiliation with Brain Research New Zealand	3 (100)	3 (100)

Round ii

Māori panellists

Kendall's W showed strong agreement between the expert-raters plus peer-rater and investigator group (Table 3) and that the *a priori* level of agreement was achieved. As a result, no further rounds were necessary. Kendall's W was statistically significant, suggesting that the panellists and investigator group applied essentially the same ratings. The Spearman's rank correlation coefficients (Table 4) showed medium to strong relationships between the panellists and investigator group, further supporting their agreement. The ICC for the sample ratings between the pairwise comparison of cognitive-load rating indicated excellent inter-rater reliability. All the activities and their median values are presented in Supplemental 2.

Non-Māori panellists

Spearman rank-order correlation coefficients between panellists in pairwise comparisons were medium for expert rater-1 compared to expert rater-2, the investigator group, and the peer-rater (Table 4). All other bivariate comparisons were highly correlated with one another. The total sample indicated good inter-rater reliability (Table 3), however the inter-rater agreement was moderate (Table 3), and did not reach the *a priori*-specified criterion. Forty-five activities (19 physical and 26 cognitive activities) met the *a priori* determined level of consensus and therefore 136 activities (75%) were the focus of the discussion during Round iii.

Table 3 Māori and non-Māori round ii Inter-rater agreement and reliability

Tertile	Māori Expert-raters + Peer-rater + Investigator group	Non-Māori Expert-raters + Peer-rater + Investigator group
ICC [95% CI]	0.807 † [0.755, 0.850]	0.693 † [0.742, 0.841]
Kendall 's W	0.650*, ‡‡	0.529*, ‡
Note. *p < 0.0001; CI Confidence interval; ICC, intraclass correlation coefficients, reliability coefficients: † 0.75 - 1.00 excellent; Kendall's W: ‡ 0.4 to 0.59 moderate and ‡‡ 0.6 to 0.79 strong.		

Table 4 Māori and non-Māori round ii -Spearman's rank correlation coefficients

Māori					Non-Māori				
	Expert -rater 1	Expert -rater 2	Investigator group	Peer-rater		Expert -rater 1	Expert -rater 2	Investigator group	Peer-rater
Expert-rater 1	1	0.602*, ††	0.542*, ††	0.624*, ††	Expert-rater 1	1	0.453*, †	0.497*, †	0.462*, †
Expert-rater 2		1	0.553*, ††	0.441*, †	Expert-rater 2		1	0.542*, ††	0.504*, ††
Investigator group			1	0.438*, †	Investigator group			1	0.575*, ††
Peer-rater				1	Peer-rater				1

Note. Correlation significant at * $p < 0.01$; Spearman rank correlation coefficient: † medium relationship strength of the variables (rs= 0.3 to 0.49 or -0.3 to -0.49) and †† strong /large relationship strength of the variables (rs= 0.5 to 1 or -0.5 to -1.0).

Round iii

Non-Māori face-to-face discussion resulted in re-rating 87 activities of which 19 were previously determined to have met the *a priori*-specified criterion in round ii. Discussions determined the need to re-rate the cognitive-load of those 19 activities and did not change the cognitive-load rating of the remaining 94 activities. Supplemental 3 reports the activities, their ratings, as well as an indication of whether the ratings changed between rounds ii and iii.

Various frustrations around the vagueness of the activities self-reported by LiLACS NZ participants were voiced. Dissatisfaction was specifically associated with differing interpretations of some activities. The face-to-face meeting provided the necessary platform for clarification to ensure all panellists shared an understanding

and consequently could more specifically rate the cognitive-load. Panellists suggested that duration, intensity, and frequency data would have been helpful. It was discussed that the data would have varied among LiLACS NZ participants and might not have provided much more direction to the cognitive-load ratings. Without the face-to-face meeting, the validity and quality of the cognitive-load data could have been compromised.

Discussion

To our knowledge this Delphi exercise is the first to estimate the cognitive-load of activities undertaken by older Māori and non-Māori. These results demonstrate that multi-disciplinary panellists were able to reach formal consensus on the cognitive-load of activities. Our Delphi study was modified by bringing raters together for a face-to-face discussion in round iii for non-Māori but not for Māori. Māori reaching consensus in one round, possibly further substantiates that culturally similar values, worldviews, constructs, and perceptions can influence rating of the cognitive-load of activities. Identifying differences in consensus between the two groups of panellists within this study substantiates independently collecting and analysing Māori and non-Māori data.

Most Māori (86%) and non-Māori (68%) cognitive-load ratings were within the middle range of the Likert-scale: 5 to 7. In Māori and non-Māori, only a single activity received a maximum cognitive-load rating of 9, which might reflect the lack of extremely cognitively demanding activities self-reported by LiLACS NZ participants.

Three studies (Karp et al., 2006; Salthouse et al., 2002; Wilson et al., 1999) assessed the cognitive-load of similar activities to ours. Salthouse et al. (2002) reported that participants rated the cognitive demand of 22 activities on a 5-point Likert-scale. Similarly, Wilson et al. (1999) asked a panel to rate the cognitive intensity of 7 activities on a 5-point Likert-scale. Karp et al. (2006) applied a 3-point Likert-scale to determine the mental component score for 29 activities, which were validated by non-study older adults.

Watching television was consistent across all studies, and it was rated 2 (moderate) by Karp et al. (2006), 2.1 (between low and moderate) by Salthouse et al. (2002), and 2.2 (on a 5-point Likert-scale where the range of cognitive-load was not defined and higher numbers indicate more effort) by Wilson et al. (1999). These results resemble our non-Māori rating of 3 (low). However, our Māori rating of 5 (neither low nor high) was the highest cognitive-load for watching television when compared to non-Māori findings, potentially demonstrating differences in the

cognitive-load ratings of an activity between cultures. This may indicate that Māori are typically more cognitively engaged while watching television than non-Māori, who may be more likely to watch television passively. This possible rationale is further supported by the description from Salthouse et al. (2002) regarding the differences in people's approaches to watching television.

Only Karp et al. (2006) included physical activities – "walk" and "doing sport", which were both rated as 1 (low). In comparison, within our study the rating for walking was a 5 (neither low nor high) for Māori and was a 4 (rather low) for non-Māori. Our physical activities that could be described as "doing sport" (e.g. 10 pin bowling, indoor/outdoor bowling, golf, or tennis) had ratings that ranged from 7 to 8 (high to very high) for Māori and 6 to 8 (rather high to very high) for non-Māori. The vast difference in the cognitive-load of physical activities between our study and Karp et al. (2006) is potentially due to the engagement of cognitive domains during physical activity being not fully recognised (Fallahpour, Borell, Luborsky, & Nygård, 2015). This perspective is not necessarily accurate, as physical activity engages cognitive domains such as the motor and sensory (Raichlen & Alexander, 2017). Owing to the various demands on the cognitive domains during different physical activity, it is possible to deduce that "doing sport" carries a greater cognitive-load than walking, as demonstrated by the findings in our study.

Karp et al. (2006) and Salthouse et al. (2002) rated the cognitive-load of “playing music” as 2 (moderate) and “music” as 3.2 (moderate), respectively. It is unclear if Salthouse et al. (2002) used the term “music” to describe listening to music or playing music, so we compared our findings to Karp et al. (2006). In comparison, our Māori and non-Māori ratings for playing musical instruments were 7 (high). The details provided in the name of an activity guides raters to assign the cognitive-load. It is possible that “playing music” is ambiguous as it could refer to playing a musical instrument or pressing play on a device, which might have contributed to the variability between the studies.

The cognitive-load ratings in the above studies (Karp et al., 2006; Salthouse et al., 2002; Wilson et al., 1999), potentially highlight the implications of the variability of study designs and populations on cognitive-load ratings. A Delphi exercise may provide a more accurate approach by evening out the variability in estimates of cognitive-load. Furthermore, ensuring that the data we obtained were culturally specific provided insight into the variability of cognitive-load ratings, which different worldviews may directly influence.

To date, pharmacological interventions have limited utility to “cure” or slow down the progression of cognitive decline. This inertia has led to investigating non-pharmacological interventions, like engagement in concurrent physical

activities and cognitive activities, because their cognitive-load could contribute to neural plasticity and cognitive benefit. The measurement of cognitive-load is important in the continued evaluation of physical and cognitive activities to unpack their cognitive benefits and role in postponing cognitive decline. The cognitive-load ratings ascertained through this Delphi study could be applied in future observational studies and randomised controlled trials in the evaluation of physical activities and cognitive activities particularly their role in cognitive change.

Strengths and limitations

This study was designed, implemented, and reported in accordance with CREDES (Jünger et al., 2017), resulting in a robust formal consensus building method to estimate the cognitive-load of activities for Māori and non-Māori. Strengths of this study included: flexible design, high response, and nil attrition rates. Round ii and the reporting of findings preserved the anonymity of panellists, facilitating their freedom of expression. Round iii facilitated discussion for non-Maori. The contributions of all panellists received equal consideration and weight in the rating process. These various features likely enhanced the validity of our study results (Hasson, Keeney, & McKenna, 2000).

This study also has limitations, and there is some debate over the validity of a consensus-building process, such as anonymised response, because it may reduce panellists' sense of personal responsibility for the end product and potentially leads to poorly considered responses (Goodman, 1987). Bias is possibly also introduced by the content of the round i questionnaire and the purposive selections of panellists (Jones & Hunter, 1995). However, we included panellists from various clinical/research backgrounds; older adult from Māori and non-Māori cultural backgrounds; and experts in psychology, psychiatry, and/or geriatrics who had some involvement with Brain Research NZ. Our objective was that this collegial connection would decrease the occurrence of attrition during rounds.

On balance therefore, we believe that our sample of Māori and non-Māori provided culturally valid cognitive-load ratings for each of the activities. Readers will need to assess the transferability of our results to their setting, but the heterogeneous multi-disciplinary composition of the panellists provides diverse insight (Mullen, 2003) into the ratings determined separately for Māori and non-Māori. The ratings achieved in this study provide a cross-sectional consensus opinion of cognitive-load at this time, for these two particular cohorts, and has the potential to inform and stimulate future studies (Hasson & Keeney, 2011).

To the best of our knowledge there is no agreement on what constitutes small or large samples in Delphi studies (Akins, Tolson, & Cole, 2005). Typically, the size of a sample depends on panellist availability and resources (Akins et al., 2005). It has been suggested that between 7 and 12 panellists is a necessary sample size (Mullen, 2003) but others recommend basing sample sizes on empirical evidence (Akins et al., 2005). Although the recommended sample size is yet to be clearly defined, our sample might have been considered small.

Conclusion

In conclusion, despite the limitations, as well as challenges described by our panellists, a consensus-based cognitive-load rating for all 181 activities was achieved for Māori and non-Māori. Future studies are necessary to evaluate the validity and reliability of the cognitive-load rating reported in this study, to ensure generalisability and consistency within future studies evaluating the cognitive-load of activities.

Conflict of Interest to Declare

The authors have no conflicts of interest to disclose.

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Supplement 1 Investigator group examples of cognitive-load ratings

When the investigator group discussed the cognitive-load of the activities, the following were considered:

- Format, such as time pressure, complexity;
- Components, such as need for concentration;
- If the activity was individual or entailed interaction with others.

Older adults are less likely to add new activities to their routine (Strain, Grabusic, Searle, & Dunn, 2002), suggesting that their engagement is within activities that are familiar to them. Considering this, the average amount of cognitive-load per activity was taken into consideration during rating.

Psyching-up approaches, positive self-talk, and/or imagery were taken into account. As these strategies typically occur before one's engagement with activities, their potential effects on the cognitive-load were not applicable in this study objective (Tod, Iredale, McGuigan, Strange, & Gill, 2005), as our aim was to determine the cognitive-load of engagement in the activity itself.

When determining the cognitive-load of physical endurance activities, we examined the psychological coping strategies used by non-elite athletes as noted in the literature such as, 'hitting the wall'. Among non-elite athletes the most common deliberate strategy was to try to remove normal sensory feedback (Buman, Omli, Giacobbi Jr, & Brewer, 2008; Laasch, 1995). This resulted in little impact on cognitive-load since alleviation of the discomfort enabled them to continue the activity (Laasch, 1995).

Below are 3 physical activities with a narrative description of their cognitive-load, collectively determined by the investigator group during piloting, therefore the rating may have changed between rounds.

Yoga was rated a 6

Yoga requires an individual to watch and/or listen to the instructor; coordinate one's body with the instructor including their movement and posture-holding (self-monitoring), breathing, and meditation. In addition, being instructed in a group environment can increase the environmental

stimulation. The stimulus augments the incoming information for processing. This may cause a person to compare themselves to their peers and push themselves, creating internal competition to excel, or a need to concentrate on themselves while minimising external distractions.

Singles tennis was rated an 8

Tennis is unpredictable: the shot selection, point length, strategy, weather, duration of the match, and the opponent. There is variability with every ball an opponent returns; it may have different velocity, rate of spin, and can be aimed at any area of the court, requiring one to react and respond quickly. Tennis requires engagement of large and small muscle groups and joints to ensure optimum position (self-monitoring) to make contact between the racket and ball during stroke and serve execution. Also, one may be interpreting their opponent's: strategies and/or weakness, shot patterns and/or shot selection, current position, and/or movement on the court. This information is taken into consideration and simultaneously applied to their own position on the court, to determine where the ball will land on the court, what type of shot they should respond with and a plan of action such as, staying at baseline or moving up to the net.

Rowing on a machine at a gym was rated a 3

This activity is completed independently and is relativity automatic; one sits on the machine's seat, picks up and holds the rowing cable, and begins the rowing motions. Rowing engages the several large muscle groups that are required to complete each repetitive rowing movement.

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Supplement 2 Māori median cognitive-load ratings from round ii

Activities	Māori median cognitive-load rating
teaching business plan	9
yoga	8
worked on family tree album	8
tennis doubles	8
teaching piano	8
tai chi	8
studying	8
square dancing	8
scottish dancing	8
research	8
pilates	8
line dancing	8
history class at UofA	8
green stone carving	8
exercise workout videos	8
engineering	8
darts	8
bridge	8
billiards/snooker	8
ballroom dancing	8
accounting work	8
zumba	7
writing	7
workshop	7
wood working/carpentry	7
welding	7
tennis	7
teaching knitting	7
tatting	7
tapestry	7
table tennis	7
sudoku	7
singing	7
scrabble	7
rummy club	7
rummy	7
ride scooter	7
ride bike/cycling	7
ride 4 wheelers	7
pottery	7
playing piano	7
playing organ	7
pig hunting	7
pétanque	7
patch work	7
painting	7

outdoor bowling	7
otago exercise program	7
organising/planning personal docs	7
needle work	7
meetings	7
mahjong	7
letter to editor	7
jig saw puzzle	7
indoor bowling	7
golf	7
genealogy	7
fly model airplanes	7
fancy work	7
exercise class	7
embroidery	7
electrician	7
driving motor bike	7
driving boats	7
driving	7
drawing	7
dance	7
crosswords	7
cross stitch	7
croquet	7
craft/hand crafts	7
cooking/baking	7
computer work	7
computer games	7
computer drafting	7
computer	7
code cracker	7
cards	7
building	7
board games	7
balance exercises	7
art class	7
aqua aerobics	7
aerobics	7
admin/ref sport	7
500	7
10 pin bowling	7
yard maintenance	6
weaving	6
watching children	6
watching acts	6
warming up exercises	6
waling backwards	6
u3a club	6
track clearance	6

swim	6
strength exercises	6
step ups	6
spinning	6
socialising	6
sit dancing	6
shell work	6
sewing	6
rose society	6
resistance training	6
recuperative exercise	6
reading	6
push ups	6
probus	6
physio-exercises	6
photography	6
muscles	6
mow lawn / trim hedge	6
mosaics	6
making fish tackle	6
making crayfish pots	6
make model airplanes	6
lifting weight	6
leg exercise	6
knit	6
kaumatua (older person) activities	6
joint exercises	6
jogging	6
indoor exercise	6
hook rug making	6
hobby tube electronics	6
hiking	6
heavy work	6
gym	6
gardening	6
free weight	6
flower arrangements	6
floor exercises	6
flax work	6
fishing	6
farm chores	6
exercise machines	6
exercise	6
crochet	6
coffin club	6
church visits	6
church activities	6
cardio	6
cardiac gym exercises	6

ball exercises	6
whakapaihia te whare (house cleaning)	5
watching television	5
watching movies	5
walking	5
twisting exercises	5
treadmill	5
stretching exercises	5
stamina exercises	5
sit be fit mobility	5
shoulder exercises	5
rowing	5
prayers	5
meditation	5
lotto	5
listening to radio	5
laundry	5
jogging on treadmill	5
household chores	5
hikoi haere (organized walk)	5
gather puha (plants)	5
climbing stairs	5
chest exercise	5
chair stretches	5
back exercises	5
audiobooks	5
arm exercise	5
aqua walking	5
aqua jogging	5
ab king pro exercise	5
standing exercises	4
listening to music	4
toe touching	1
rest/relaxing	1
neck exercise	1
breathing exercises	1

Supplement 3 Non-Māori medians cognitive-load ratings from round iii and an indication of median change between rounds

Activities	Consensus Median Score from Round iii	Median score changed between Rounds ii and iii
admin/ref sport	9	Yes
tennis doubles	8	No
pig hunting	8	Yes
square dancing	8	Yes
teaching piano	8	No
bridge	8	No
building	8	No
electrician	8	No
engineering	8	No
research	8	No
billiards/snooker	7	No
outdoor bowling	7	No
croquet	7	Yes
darts	7	Yes
table tennis	7	No
golf	7	No
tennis	7	No
track clearance	7	Yes
scottish dancing	7	No
ballroom dancing	7	No
playing piano	7	Yes
playing organ	7	No
sewing	7	Yes
tapestry	7	Yes
embroidery	7	Yes
tatting	7	No
teaching knitting	7	No
rummy	7	No
mah-jong	7	No
scrabble	7	No
500	7	Yes
rummy club	7	No
cards	7	Yes
code cracker	7	No
sudoku	7	No
fly model airplanes	7	No
farm chores	7	Yes
cooking/baking	7	No
wood working/carpentry	7	Yes
history class at UofA	7	Yes
letter to editor	7	Yes

accounting work	7	Yes
teaching business plan	7	Yes
watching children	7	Yes
driving motor bike	7	No
driving	7	No
ride scooter	7	Yes
driving boats	7	No
ride bike/cycling	6	No
aerobics	6	No
exercise class	6	No
tai chi	6	Yes
yoga	6	No
indoor bowling	6	Yes
pétanque	6	Yes
hiking	6	No
fishing	6	No
zumba	6	No
dance	6	Yes
line dancing	6	Yes
singing	6	Yes
crochet	6	No
cross stitch	6	No
knit	6	No
spinning	6	No
weaving	6	No
fancy work	6	No
needle work	6	No
hook rug making	6	Yes
patch work	6	No
art class	6	No
craft/hand crafts	6	No
drawing	6	Yes
green stone carving	6	Yes
flax work	6	No
painting	6	Yes
shell work	6	No
flower arrangements	6	No
mosaics	6	No
pottery	6	Yes
board games	6	No
computer games	6	Yes
jig saw puzzle	6	Yes
crosswords	6	Yes
making fish tackle	6	Yes
making crayfish pots	6	No
make model airplanes	6	No
photography	6	No

hobby tube electronics	6	Yes
heavy work	6	Yes
workshop	6	Yes
welding	6	No
gardening	6	No
studying	6	Yes
writing	6	Yes
computer drafting	6	Yes
worked on family tree album	6	Yes
organising/planning personal docs	6	No
genealogy	6	Yes
probus	6	No
rose society	6	Yes
meetings	6	Yes
church visits	6	No
coffin club	6	Yes
church activities	6	No
kaumatua (older person) activities	6	Yes
u3a club	6	Yes
ride 4 wheelers	6	No
meditation	6	No
gym	5	Yes
jogging	5	No
otago exercise programme	5	No
free weight	5	No
exercise workout videos	5	Yes
lifting weight	5	No
resistance training	5	No
ball exercises	5	Yes
aqua aerobics	5	No
pilates	5	Yes
10 pin bowling	5	Yes
hikoi haere (organized walk)	5	Yes
sit dancing	5	No
watching acts	5	Yes
household chores	5	No
laundry	5	Yes
gather puha (plants)	5	No
whakapaihia te whare (house cleaning)	5	Yes
reading	5	Yes
computer	5	Yes

computer work	5	Yes
socialising	5	Yes
prayers	5	No
cardio	4	No
muscles	4	No
balance exercises	4	Yes
cardiac gym exercises	4	Yes
exercise machines	4	Yes
floor exercises	4	No
indoor exercise	4	Yes
recuperative exercise	4	No
step ups	4	No
strength exercises	4	No
waling backwards	4	Yes
warming up exercises	4	Yes
stamina exercises	4	Yes
physio-exercises	4	No
walking	4	No
mow lawn / trim hedge	4	No
yard maintenance	4	No
rowing	3	No
jogging on treadmill	3	Yes
back exercises	3	No
climbing stairs	3	Yes
leg exercise	3	No
stretching exercises	3	Yes
treadmill	3	No
joint exercises	3	Yes
shoulder exercises	3	No
standing exercises	3	Yes
twisting exercises	3	Yes
exercise	3	Yes
swim	3	Yes
aqua jogging	3	No
aqua walking	3	No
watching movies	3	No
watching television	3	No
listening to radio	3	Yes
audiobooks	3	Yes
listening to music	3	No
ab king pro exercise	2	Yes
push ups	2	Yes
sit be fit mobility	2	Yes
chair stretches	2	Yes
chest exercise	2	Yes
lotto	2	No

arm exercise	1	Yes
breathing exercises	1	Yes
neck exercise	1	Yes
toe touching	1	Yes
bending exercises	1	No
rest/relaxing	1	No