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LUCID DREAMING INCIDENCE: A QUALITY EFFECTS META-ANALYSIS OF 50 YEARS OF RESEARCH

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1. Introduction

Dreams in which the dreamer becomes aware they are dreaming are known as 'lucid dreams' (LaBerge & Rheingold, 1990). Hearne (1978) and LaBerge (1980) demonstrated that lucid dreams represent an objectively verifiable altered-state of consciousness when showing participants could signal their lucid state, during dream periods, using pre-agreed eye-movement signals when becoming aware during a dream. While this shows that certain people under certain conditions can achieve awareness during dream states, it tells us little about their occurrence *in situ* among the general public. Knowledge of this is important, if it can be established that lucid dreaming is a common experience for individuals this may act as an impetus for increased research investigating the causes of its occurrence and stimulate a greater consideration for the ways in which the experience of lucid dreaming may be utilised as a practical tool.

The most recent review of estimates of lucid dreaming incidence (Snyder and Gackenbach, 1988) distinguishes between lucid dreaming *prevalence* (the number of individuals experiencing at least one lucid dream) and *frequent* lucid dreamers (those reporting one or more lucid dreams per month). In summarising survey data, Snyder & Gackenbach report "conservative" estimates for lucid dreaming prevalence of 58% of the population with a further 21% of individuals as frequent lucid dreamers. Unfortunately it is not clear how these estimates were calculated, since the method of analysis is not described — a weighted mean would be the most likely estimation technique — and we assume that a study reporting 100% prevalence was omitted from their calculation. Weighted means for two studies (Gackenbach, et al., 1987 cited in Snyder & Gackenbach, 1988; LaBerge, 1985) could not be calculated by us as sample sizes were not reported. Calculating weighted means with these studies omitted produces rates of 62% for prevalence and 19% for frequency. Snyder and Gackenbach (1988) do not report confidence intervals for their estimates which cannot be calculated via secondary analysis without information of the total sample size (Cumming, 2011). Of concern is the high variation amongst effect size estimates in Snyder and Gackenbach's review, which the authors attribute to methodological inconsistencies between studies and differences in sample characteristics, though they do not subject this speculation to any empirical test. Since their paper was published statistical methods have been developed which enable a reduction in the impact of poor methodological features upon pooled effect size estimates. The primary aim of the current study is therefore to provide an updated meta-analytic review of studies reporting incidence data for the occurrence of lucid dreams, including additional analyses to identify sources of the variance in outcomes.

One of the potential sources of variability identified by Snyder and Gackenbach (1988) is an inconsistency in how lucid dreams are defined or exemplified when asking people about their experience of them; unclear definitions have been demonstrated to lead to participant error that can affect as much as a fifth of a sample (Gackenbach, 1988). Whereas Green and McCreery (1994) argue that lucidity is sufficiently defined as the dreamer being aware they are dreaming, Tart (1988) argues for the earlier conceptualisation of lucid dreams as presented by van Eeden (1913) which requires that the dreamer has complete memory of their waking life and is able to exert control over aspects of the dream. This latter definition is problematic as Voss, Frenzel, Koppehele-Gossel and Hobson (2012) found only 37% of lucid dreamers in their sample reported they could manipulate the dream. Mota-Rolim, Targino, Souza, Blanco & Araujo

(2013) also report only 25.2% of their sample claimed very frequent or consistent control within lucid dreams. Despite control being highlighted as a key element of lucidity alongside disassociation and insight (Voss & Hobson, 2015) these findings suggest that control is not in itself a qualifying criterion necessary to determine whether a lucid dream has been experienced. Tart & Van Eeden's definition with its emphasis on control may therefore be useful in differentiating between 'degrees' or 'depths' of lucidity, however using it as a definitive definition to the exclusion of dream experiences which lack control but retain other characteristics such as insight and disassociation may provide us impoverished estimates of lucid dreaming incidence. Therefore in this paper the broader definition of lucid dreaming shall be adopted in an effort to provide the most valid estimates of lucid dreaming incidence[1].

Additionally, Snyder and Gackenbach (1988) report prevalence rates are reduced (i.e. false positives are avoided) in studies where an example dream narrative — a written verbatim account of a dream from the perspective of the dream experient — is given alongside a definition of lucidity. This approach has been more recently recommended as good practice (Schredl, Henley-Einon & Blagrove, 2012) and has been adopted by a number of researchers (e.g., Erlacher, Schredl, Watanabe, Yamana & Ganzert, 2008; Voss, Frenzel, Koppehele-Gossel & Hobson, 2012). Others have asked participants to produce an example narrative of their own lucid dreams (Gackenbach, Heilman, Boyt & LaBerge, 1985) which can be used to identify misunderstandings. Here LaBerge (1985) reports a drop in prevalence rates from 85% to 77% while Gackenbach, Heilman, Boyt & LaBerge, 1985) reduced their lucid dreamer sample from 707 to 360 after an analysis of participant-provided dream narratives demonstrated 347 were either clearly or questionably not lucid.

A third factor identified by Snyder and Gackenbach (1988) is the method of data collection, with the most common approach using self-report being susceptible to errors common in retrospective recall (Hassan, 2005; Schacter, 1999). Here the format of the response scale can also be problematic, where a range of Likert-scales have been utilised for investigating lucid dreaming frequency, ranging from 3 to 9 point scales. Providing a wide enough response range for participants is important so subtle differences between frequency estimates are distinguishable; Lozano, García-cueto & Muñiz (2008) show reliability and validity of psychometric scale responses are directly affected by the sensitivity of the scale used, with a seven point scale being considered optimal.

These are all key characteristics for which the methodological quality of a study in this area can be judged and must be considered as potential influencing factors on any final estimates provided.

Additionally, with the introduction of new data collection methods in recent decades the method of data collection was considered a potential factor influencing estimates, particularly with the increasing utilisation of online data collection methods (Benfield & Szlemko, 2006). Manual and electronic survey collection methods have been examined for potential issues of comparable validity and reliability. Studies have found test-retest reliabilities to be nearly equal, internally consistent, with high predictive validity and comparable socio-demographic recruitment trends between the two formats (Banov, Kongsved, Bech & Hjollund, 2009; Berrens, Bohara, Jenkins-

[1]Here we focus on the simple definition of lucid dreaming for ease of participant understanding in incidence studies, proposing insight as the principle lucid dream defining criteria. However the authors wish to acknowledge this is a more complex debate, please see (Kühle, 2015; Noreika, Windt, Leggenhager, & Karim, 2010; Windt & Metzinger, 2007).

Smith, Silva, & Weimer, 2003; Lewis, Watson & White, 2009; Schilewaert & Meulemeester, 2005; Sethuraman, Kerin, & Cron, 2005; Vosylis, Malinauskiene & Zukauskiene, 2012) with internet surveys in some instances providing greater diversity of respondents (Lewis, Watson & White, 2009). This indicates that both formats are generally reliable, assuming the questions posed are valid and participants are truthful in their responses. Overall the method of data collection used (electronic or manual) does not appear to impact on the type of respondent recruited, nor does it impact on the quality of data provided by that respondent. To test this assumption, a comparison of study estimates via forest plot for data collection method was conducted (See supplementary material) which demonstrated little difference between a pooled prevalence estimate of online studies (65%, 95% C. I. [55%, 75%]) in comparison to postal surveys (60%, 95% C. I. [51%, 68%]) surveys completed with the researcher present (57%, 95% C. I. [47%, 57%]) and surveys where participants were given the measure in person to complete in their own homes and return at a later date (59%, 95% C. I. [29%, 87%]). Thus despite online studies on the whole providing higher pooled estimates, the degree of overlap with estimates of other methods highlights this is not a factor pertinent as a quality-assessment criterion. Despite this, information regarding each studies data collection method is provided in Table 1.

The current meta-analysis further provides an opportunity to identify participant characteristics associated with the propensity to experience lucid dreams. It has been found that children and adolescents report dreaming lucidly more often than other age groups (Blackmore, 1984; Gackenbach, 1980; Palmer, 1979: Schredl and Erlacher, 2004, 2011; Voss et al., 2012, Watson, 2001). In an effort to explain this Voss et al. (2012) proposed the brain maturation hypothesis, postulating that lucid dreaming is a disassociated, hybrid neurobiological state which occurs as an epiphenomenon of the brain's natural maturation processes, such that higher frequency of lucid dreams would be reported from adolescence until the early years of adulthood at which point frequency would decline for the majority of people.

Additionally, it has been suggested that lucid dreaming represents a specialised form of mental imagery. Mental imagery can be defined as "a symbolic sensory experience that may occur in any sensory mode" (Hardy, Jones & Gould, 1996). Lucid dreaming has been linked to waking imagery vividness as measured by the Betts Inventory (Gackenbach, Prill & Westrom, 1983) to visual and auditory imagery (Hearne, 1983) to gustatory, kinaesthetic, olfactory and tactile waking imagery tasks (Kueny, 1985) and also has some overlap with the mental training of motor-imagery, commonly experienced by professional athletes (Erlacher & Schredl, 2008, 2010; Tholey, 1990). Motor-imagery (the mental rehearsal of physical skills, without the motor-execution of the actions involved) is the variant of mental imagery most frequently applied to sports and the frequency with which sports professionals utilise these techniques is shown to be between 70-90% (Cumming & Hall, 2002) making many athletes adept at mental imagery. Athletes may therefore be more likely to experience lucid dreams due to their regular immersion in imaginary environments as an aspect of their day-to-day training. Furthermore athletes may receive practical gains from lucid dreaming experiences, an online survey found 21.3% of 301 of frequent lucid dreamers report utilising their lucidity to practise waking skills (Schädlich & Erlacher, 2012). Exploratory research has also shown lucid dreaming practice may improve waking task performance (Erlacher & Schredl, 2012; Stumbrys, Erlacher & Schredl, 2016). This evidence implies that actions performed within lucid dreams corresponds to physiological arousal within the body, supporting the notion of some shared central neural structures between imagined, dreamed and executed motor actions

(Erlacher & Schredl, 2008). Athletes may therefore be particularly motivated to cultivate lucidity for the practical benefits it potentially provides. They also possess the necessary commitment levels and mental toughness (Crust, 2007) to succeed in their sport professionally, which may make them cognitively well equipped to succeed in the application of lucid dreaming induction techniques.

Culture, as the shared beliefs, attitudes, norms, role perceptions and values of a group of individuals (Triandis, 2002) may also have an influence on lucid dreaming incidence. Differences in dream content (Nielsen et al., 2003; Schredl, Ciric, Gotz & Wittman, 2004; Yu, 2008) and its interpretation (Spaulding, 1981; Lohmann & Dahl, 2014) have been observed between cultures. An individual belonging to a culture which ascribes importance to dreams may spend a greater amount of time recording and reflecting upon them; important prerequisites of high dream recall (Condron, 1994), and subsequently dream lucidity (LaBerge & Rheingold, 1990). Cultural awareness of lucid dreaming may also determine whether a lucid dream is correctly identified. For example, racial differences in lucid dreaming frequency between African-American and Caucasian participants have been reported by Palmer (1979). Erlacher et al. (2008) also highlights clear differences in incidence estimates for Japanese and Chinese samples when compared to European samples. Furthermore similarities have been drawn between the phenomenal aspects of lucid dreams, out-of-the-body experiences (Levitan & LaBerge, 1991) alien abductions and near death experiences (Gackenbach, 1991). In some cases individuals may incorrectly interpret a lucid dream as one of these experiences due to a limited knowledge of dream lucidity. This is not to say that the associated experiences above can be comprehensively explained as misinterpreted lucid dreams (See Rogo, 1978, 1985; Salley, 1986) but may provide an explanation for some of the variance between sample estimates.

Culture may also play a role in the engagement in/avoidance of activities associated with lucidity (Laughlin, 2011; Lohmann & Dahl, 2014). Certain meditative states such as mindfulness meditation share commonalities with lucid dreaming, where attention is focused upon one's current state of consciousness (Kühle, 2015; Pagal, 2014; Schredl, 2010). Hunt (1987, 1989) argues that lucid dreaming contains elements of detached receptivity and enhanced self-awareness reflective of the desired goals of meditative practice. Drawing on his own lucid experiences and those of Gillespie (1984) Sparrow (1976) and Van-Eeden (1913) Hunt argues lucid dreams and meditation both correspond closely in their experiential qualities. In addition, eastern spiritual traditions which address lucid dreaming such as the practices of "dream yoga" or "Milam" in Tibetan Buddhism (Chang, 1963; Wangyal, 1998) "dream witnessing" from Hindu transcendental meditative practice (Alexander, Cranson, Boyer & Orme-Johnson, 1987) and the Dzogchen meditative approach of Zen Buddhism (Pagal, 2014) provide practitioners tools for experiencing lucid dreams as a meditative technique to attain spiritual growth. Lucid dreaming frequency and degree of meditational practice have been shown to be significantly related (Gackenbach, 1990; Gackenbach, Cranson & Alexander, 1986; Hunt & McLeod, 1984; Hunt, 1987, 1991; Reed, 1978) strengthening the proposed correspondences between the two experiences. Therefore individuals from cultures where meditative practice is widespread may be more inclined to induce lucid dream experiences (however, see Gackenbach, 1978).

Additionally cultures where video-games are popular may also have higher reported lucid dreaming prevalence and frequency rates, as frequent video game play has been associated with lucid dreaming incidence (Gackenbach, 2006, 2009; Gackenbach & Kuruvilla, 2008). Gackenbach & Hunt (2014) have proposed this may be due to significant parallels between game play and meditation and ultimately lucid

dreaming. Lucid dreaming and video-game play are both grounded in similar spatial skills (Gackenbach et al., 1985; Greenfield, Brannen & Lohr, 1996) require resilience to motion sensitivity (Gackenbach, 1982; Gackenbach et al., 1986; Preston, 1998) and focused attention (Gackenbach & Bosveld, 1989; Maynard, Subrahmanyam & Greenfield, 2005). Gackenbach & Hunt (2014) classify individuals as "hard-core" gamers if they play video games an average of several times a week, typically for periods of over two hours, if they have played video games since or prior to the third grade and have played a total of 50 or more video games over their lifetime. These hard-core gamers have a familiarity with waking immersion in virtual worlds (Calleja, 2007) which may transfer to their dream virtual worlds (Schredl, 2003) leading to an increased likelihood of experiencing lucid dreams.

Any contemporary review of the incidence literature must utilise methods that take study methodological quality and participant characteristics into consideration in order to present robust estimates of lucid dreaming incidence. An updated review, incorporating all available incidence studies (including several studies that were overlooked in the 1988 review: Green, 1966; Blackmore; 1982a, 1982b, 1982c, 1983, 1984, 1985) and utilising the meta-analytic method (Glass, 1976) is necessary. Meta-analysis aims to pool results of primary studies to provide a quantitative review of existing empirical evidence. The most frequently used method in psychology is the random effects meta-analysis, but this is considered inappropriate for synthesising studies that vary in methodological quality as biased pooled estimates and associated confidence intervals may be the result (Khalaf, Thalib & Doi, 2011). The Quality-Effects model (Doi & Thalib, 2008; 2009) attempts to avoid this biasing of the pooled estimate by taking individual studies methodological quality of into account when calculating statistical parameters. This makes the quality effects model more appropriate for the current purpose, where clear differences in study methodological quality appear to have an influence upon the a study's final estimate. Additionally, effect size estimates collected across studies from either the same participants, same settings or same researchers are commonly found to correlate and can have an inflationary influence on the effect size average (Malle, 2006). As several researchers have published more than one study in the current review, authors are to be incorporated as a moderator variable, grouping studies from the same researcher together so that potential systematic biases in reported results can be identified.

The aim of the present study is to conduct a quality effects meta-analysis of the self-reported rates of lucid dreaming incidence for frequent lucid dreamer prevalence. Study methodological quality shall be assessed and reflected in the weights ascribed to each study estimate. In addition, three moderator variables will be investigated as potential sources of heterogeneity: participant characteristics, nationality and researchers contributing more than one study. For estimates of both lucid dreaming *prevalence* and *frequent* lucid dreaming, it is expected that samples with children, athlete and video gamer participant characteristics will report higher estimates of lucid dreaming than other participant characteristic groups. Potential cultural differences on the basis of participant nationality for lucid dreaming incidence will also be explored.

2. Method

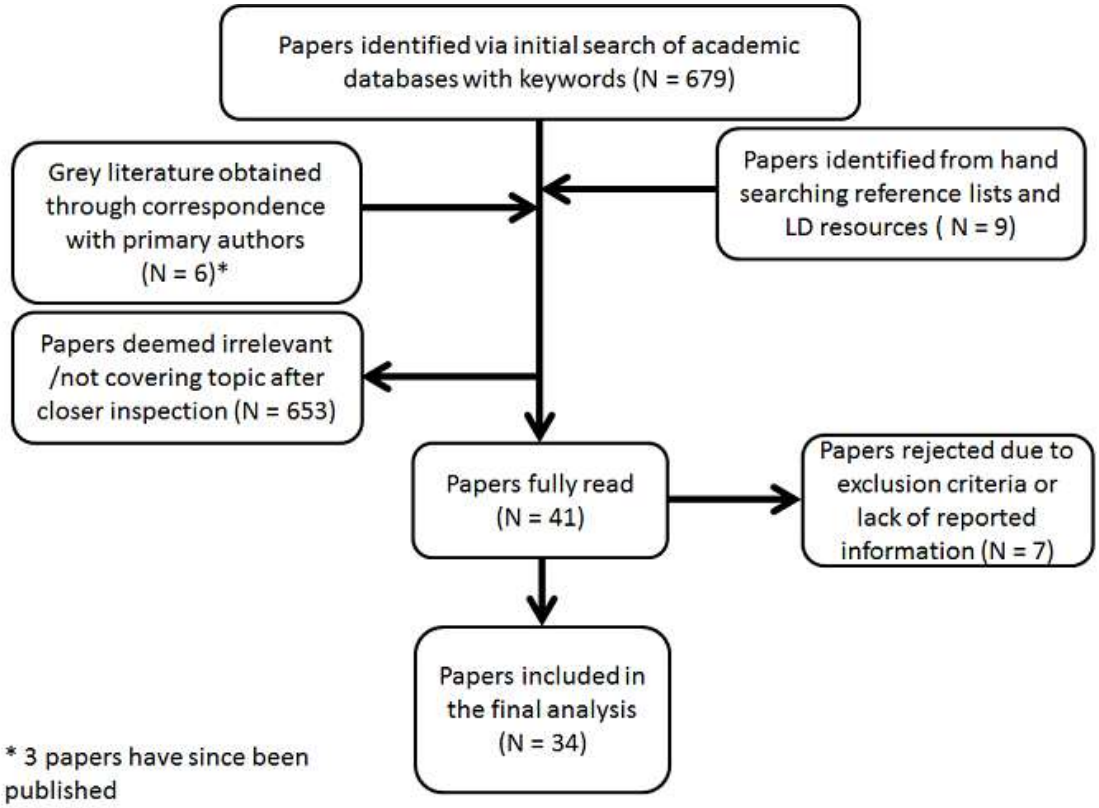
2.1. *Search strategy*

A search for studies investigating lucid dreaming incidence was conducted. No publication date restrictions were applied thus identified studies ranged from 1966-2016. Computer-based literature indexes were searched (PsychNET, Swetswise, Lexscien, IngentaConnect and WebofScience) using a combination of lucid dreaming specific terms. The terms Lucid* AND Dreaming* OR Dream* were searched, as well as terms relating to associated experiences that have been investigated in combination with lucid dreams (e.g. OBE* OR Altered-state* OR ASC* OR NDE*). Terms directly related to the occurrence of lucidity (Incidence* OR Prevalence* OR Frequency*) and terms of common research methodologies (e.g. Survey* OR Collection* OR Self-Report*) were also searched. Identified abstracts were read to assess a paper's relevance before moving to a careful hand search of appropriate reference lists, books and other relevant resources. Once these sources were exhausted correspondence was attempted with all primary authors to identify grey literature on the topic, see Figure 1 for a flow diagram of the identification process.

2.2. *Inclusion/Exclusion criteria*

For inclusion in the meta-analysis studies had to meet the following criteria: (1) Studies provided at least one measure of lucid dreaming incidence (2) studies were written in English (3) Data collection was by self-report measure or interview. (4) Studies did not select participants on the basis of pre-determined characteristics such as high dream recall frequency or experience at lucid dreaming. Of the initial 679 papers identified, of these 653 were not relevant, did not meet inclusion criteria or lacked sufficient details to allow proportions to be calculated. A further 9 additional papers were identified through hand searching and these were augmented by a further six ‘grey literature’ studies provided via e-mail correspondence sent to every author who had published a study included in the review, requesting if any unpublished manuscripts/data were available from them. Seven papers were then rejected due to the exclusion criteria or lack of detail, leaving a total of 34 papers included in the analysis.

Figure 1: Flow Diagram of the study identification process



2.3. *Data extraction*

Data on sample nationality; definition of lucidity used; sampling method; sample size; measurement protocol; measurement instrument; measurement of moderators; methodological controls and relevant participant characteristics were taken from every study included within the meta-analysis. When reporting for any of the above was unclear correspondence with the authors was attempted for clarification.

2.4. *Quality Assessment and Coding Procedure*

No available scale was appropriate for the task; two of the most effective quality assessment scales (Deeks, et al., 2003) the Downs & Black scale (Downs & Black, 1998) and the Newcastle-Ottawa Scale (Wells et al., 2014), lacked items which sufficiently addressed internal validity dimensions relevant to the lucid dreaming incidence literature. Therefore a 12-item scale, the Lucid Dreaming Incidence Methodological Quality inventory (LDIM-Qi) was devised with questions addressing the three broad dimensions of reporting quality, external validity and internal validity (See Appendix I). The total available points on this scale are 18 with the majority of questions being scored 0 or 1. Questions 2, 3, 5, 7, 11 & 12 have a maximum score of

two, with one point being awarded for limited coverage. Items within the reporting and external validity subsections are general and concern clarity of hypothesis/aims /objectives, representativeness of sample etc. The internal validity scale considers specific issues, devised from a consideration of the methodological differences that exist between studies and the relative impact these may have on the accuracy of findings

Quality scoring for the studies was completed by the primary author, then a random selection of studies were assessed by a second, blinded judge, these scores were then correlated. Overall a high degree of reliability was found between both judges for the scores provided on the LDIM-Qi scale measurements. The degree of correspondence between judges was shown by a Spearman's ranked correlation coefficient ($r_s = .928$, 95% C. I. [.80, .97] $p < .001$, $n = 17$). Please see the supplementary material of this paper for Qi scores for each study.

Once studies were scored on the quality assessment measure separate quality effects analyses were run, for studies reporting rates of either lucid dreaming prevalence or frequent lucid dreaming, studies reporting both appear in both analyses. Potential sources of heterogeneity were investigated by the arrangement of studies into groups dependent on the moderator variables of sample characteristics (students, children, representative, athletes, interest groups, video-gamers and researcher groups), sample cultural background (British, American, German, Swiss, Dutch, Austrian, Japanese, Chinese & Brazilian) and researcher/research group. All analyses were completed using SPSS XXII (IBM Corp, 2013) and MetaXL V4.01 for Microsoft Excel (Barendregt, Doi, Lee, Norman & Vos, 2013).

3. Results

The final sample included 34 studies spanning five decades of research with a total n of 24,282 comprised of differing sample types (student n = 3,355; representative = 7,300; children = 4,162; interest groups (individuals who have engaged with the research due to an explicit interest in the topic area) = 6252; Research groups (samples comprising individuals belonging to research societies such as the Society for Psychical Research; the Association for Research and Enlightenment) = 886; Athletes = 2235; Video gamers = 92). These participants also represented diverse nationalities (British = 6,393; Brazilian = 3427; German = 3,190; American = 1,842; Japanese = 1,476; Austrian = 1,000; Spanish = 254; Chinese = 348; Swiss = 214; Dutch = 189) the remaining 5949 participants were from online survey studies where no data for nationality was collected (Hess et al., 2016; Schredl et al., 2014; Stumbrys, Erlacher & Malinowski, 2015) Simple means for lucid dreaming prevalence and frequent lucid dreamers are reported in Table 1 as 63.25% and 23.27% respectively. Alongside this data collection method, sample characteristics, participant nationality and final Quality index score (Qi) ranging from 0 (meeting no methodological quality criteria) to 1 (fully meeting all criteria) is provided for each included study. The mean overall Qi score is shown as .46, in order to assess if study quality improved over time, a spearman's correlation was conducted between year of publication and Qi score, this was shown as non-significant ($r_s = .146$, $p = .409$, $n = 34$) suggesting study quality has not improved significantly over time.

Table 1: Estimates of lucid dreaming with percentages for lucid dreaming prevalence and frequent lucid dreamers in the population for all studies, ordered by year of publication.

Study	Method[1]	n	%Prevalence	%Frequent	Characteristic[2]	Nationality	Qi
Green (1966)	RP	110	76%	8%	S	GB	0.28
Gackenbach (1979)	Postal	78	62.8%	NR[2]	IG	US	0.56
Palmer (1979a)	Postal	354	56%	14%	R	US	0.56
Palmer (1979b)	Postal	268	71%	29%	S	US	0.56
Kohr (1980)	Postal	406	70%	21%	RG	US	0.50
Blackmore (1982a)	RP	157	79%	15.2%	S	GB	0.39
Blackmore (1982b)	RP	114	73%	29.8%	S	GB	0.33
Blackmore (1982c)	RP	189	73%	31.2%	S	NL	0.33
Blackmore (1983)	RP	234	61%	30.7%	S	GB	0.28
Blackmore (1984)	Postal	314	47%	16%	R	GB	0.61
Blackmore (1985)	RP	187	81%	NR[2]	S	GB	0.44
Gackenbach et al. (1985)	RP	360	56.9%	20.2%	S	US	0.61
Gackenbach (1988)	RP	284	44%	NR[2]	S	US	0.28
Thalbourne (1994)	Postal	402	52%	NR[2]	RG	GB	0.44
Gackenbach (1998)	RP	92	85%	NR[2]	VG	US	0.61
Stepansky et al. (1998)	RP	1000	26%	NR[2]	R	AT	0.56
Alvarado & Zingrone (2003)	Postal	49	82%	NR[2]	IG	GB	0.17
Schredl & Erlacher (2004)	Home	439	82%	36%	S	DE	0.56
Alvarado & Zingrone (2007)	Postal	254	88%	NR*	IG	ES	0.28
Erlacher et al. (2008)	Home	153	47%	17%	S	JP	0.67
Yu (2008)	RP	348	92%	18%	S	CN	0.17
Schredl & Erlacher (2011)	Home	919	51%	20.1%	R	DE	0.72
Voss et al. (2012)	Interview	622	51.9%	26%	C	DE	0.67
Erlacher et al. (2012)	RP	840	56.55%	23.69%	A	DE	0.56
Schredl et al. (2012)	RNP	3540	44%	28%	C	DE	0.56
Fingerlin (2013)	Online	214	50%	26%	S	CH	0.56
Mota-Rolim et al. (2013)	Online	3427	77%	20.9%	IG	BR	0.50
Zink & Pietroysky (2013)	Online	332	47.7%	23.8%	S	DE	0.33
Schredl et al. (2014)	Online	2929	61.49%	25.2%	IG	NR[2]	0.56
Jones & Stumbrys (2014)	Online	72	75%	30.6%	A	DE	0.50
Erlacher et al. (2014)	RP	1323	41%	18%	A	JP	0.44
Stumbrys, Erlacher & Malinowski (2015)	Online	528	73.1%	49.8%	R	NR[2]	0.44
Hess, Schredl & Göritz (2016)	Online	2492	58.8%	24.7%	IG	NR[2]	0.56
Schredl, Henley-Einon, Blagrove (2016)	RP	1286	52.38%	8.52%	R	GB	0.44

Totals/Means	24282	63.25%	23.51%	0.46

[1]RP = Researcher Present, RNP = Researcher Not Present [2]NR = Not Reported, S = Student, R = Representative, RG = Research Group, IG = Interest Group, A = Athletes, VG = Video Gamers, C = Children.

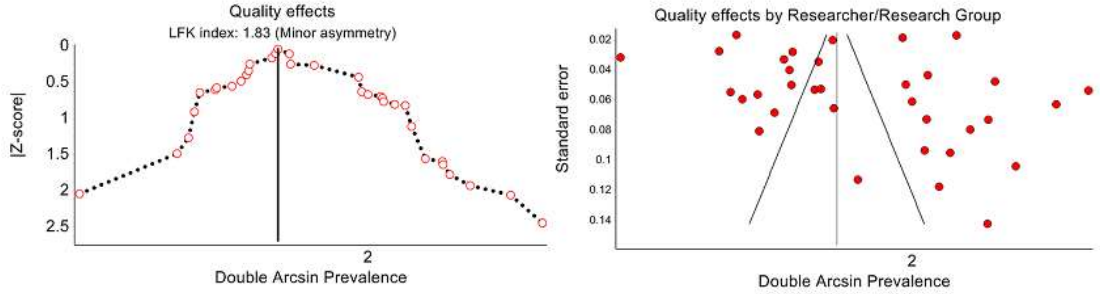
3.1. *Lucid Dreaming Prevalence*

Estimates of lucid dreaming prevalence were reported by all 34 studies (See Table 1). The Quality effects meta-analysis of these studies demonstrate a pooled estimate of 59.48%, 95% CI [51%, 67%] with estimates ranging from 26% to 92% and with heterogeneity significantly greater than zero amongst them (Q = 2511.47, p = <.001, I^2 = 99%).

3.1.1. *Publication Bias*

There was evidence of minor levels of asymmetry in the lucid dreaming prevalence study estimates. With both Doi and Funnel plots (Figure 2) showing a greater frequency of higher estimate studies. The Doi (left) and Funnel (right) plots for lucid dreaming prevalence studies are shown in figure 2 identify potential asymmetry amongst estimates. In the presence of symmetry, the Doi plot is expected to have symmetrical right and left limbs, with comparable numbers of studies on either limb.

Figure 2: Doi & Funnel plots of lucid dreaming prevalence estimates



This is also shown by the greater number of estimates to the right of the model in the Funnel plot, where the lines of the funnel represent the 95% C. I. of the model estimate (already corrected for methodological quality), as the standard error increases (i.e. studies decrease in sample size, less precise estimates are expected. . These graphs show that minor asymmetry exits with a larger proportion of studies on the right limb (higher estimates). With an LFK index score of +1.83 indicative of minor asymmetry of the estimates this suggests that publication bias or small study effects may lead pooled estimates to lean towards the higher percentiles. However this asymmetry is not substantial and may be attributable to the high levels of heterogeneity among effects (for detailed rationale for the LFK index and Doi plot, see Barendregt & Doi, .n.d.)

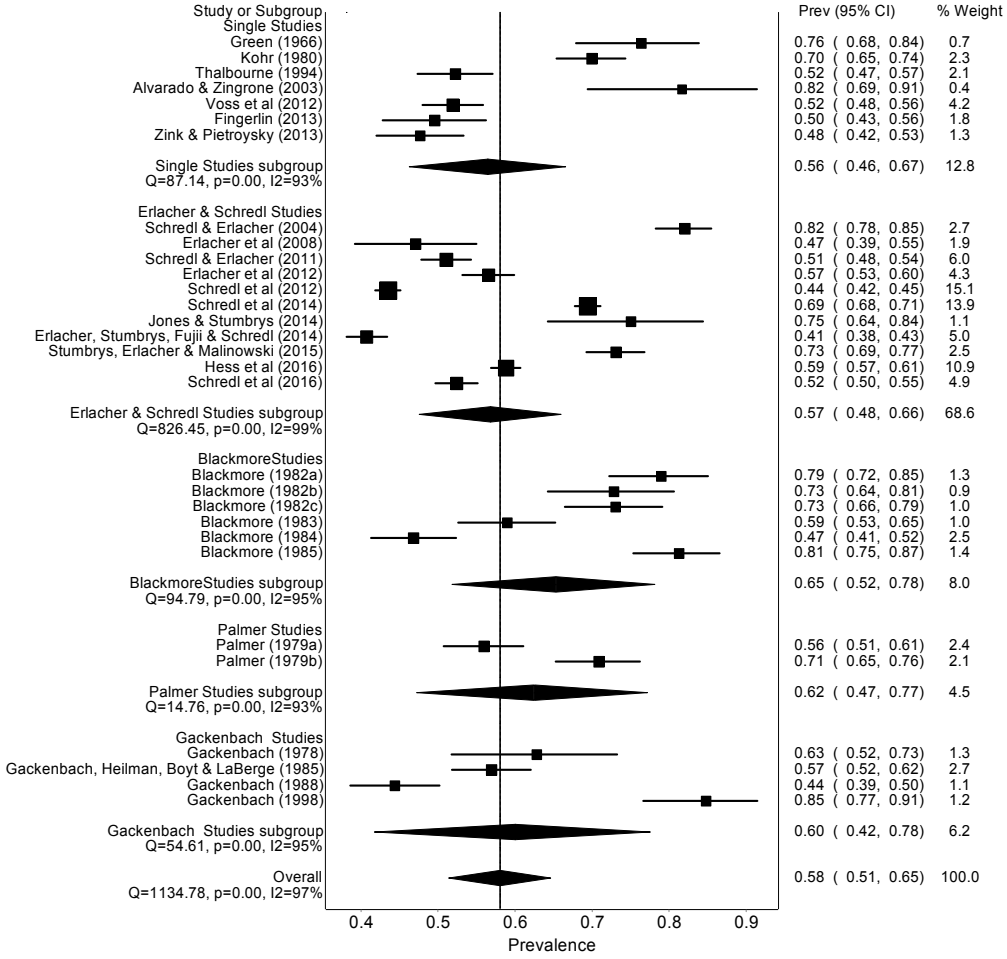
Due to heterogeneity a sensitivity analysis was conducted, which identified four studies as large contributors (Alvarado & Zingrone, 2007; Mota-Rolim et al., 2013; Stepansky et al., 1998; Yu, 2008). Although not unique to them, three of these studies investigated lucid dreaming alongside other sleep experiences and this broader focus may explain why no additional steps were taken to ensure participant understanding of what constitutes a lucid dream by these studies. Mota-Rolim et al. (2013) is the only study for which this does not apply, it is also the only study conducted on a Brazilian sample. With a large sample size, their findings may reflect a cultural difference for the prevalence of lucid dreaming, however as the sample was self-selected it is possible

that many participants were motivated to complete the study due to their own lucid dream experiences, making the prevalence rates of lucid dreaming over represented within the sample. Alvarado and Zingrone (2007) also may have this issue, recruiting from among readers of a Spanish new age magazine whose interest in paranormal and consciousness topics may have been prompted by spontaneous anomalous experiences that could inflate their prevalence figure over other samples. Overall excluding these four studies reduced total heterogeneity, though it remained significant (Q = 1134.78, $p < .001$, I^2 = 98%). With their removal the pooled estimate was reduced from 60% to 58%, with 95% confidence interval estimates becoming more precise, changing from 51%-68% to 51%-65%. In an attempt to provide explanations for remaining heterogeneity moderator analyses were conducted on the variables of researcher/research group, participant nationality and participant characteristics.

3.2.*Researcher/Research Group Moderator Analysis*

Because of concerns about violation of the independence assumption, researchers contributing more than a single study were included in a moderator analysis (Figure 3). Overall this analysis strongly indicates no researcher systematic bias, going some way to support the violation of the independence assumption.

Figure 3: Quality effects moderator analysis for lucid dreaming prevalence by researcher/research group

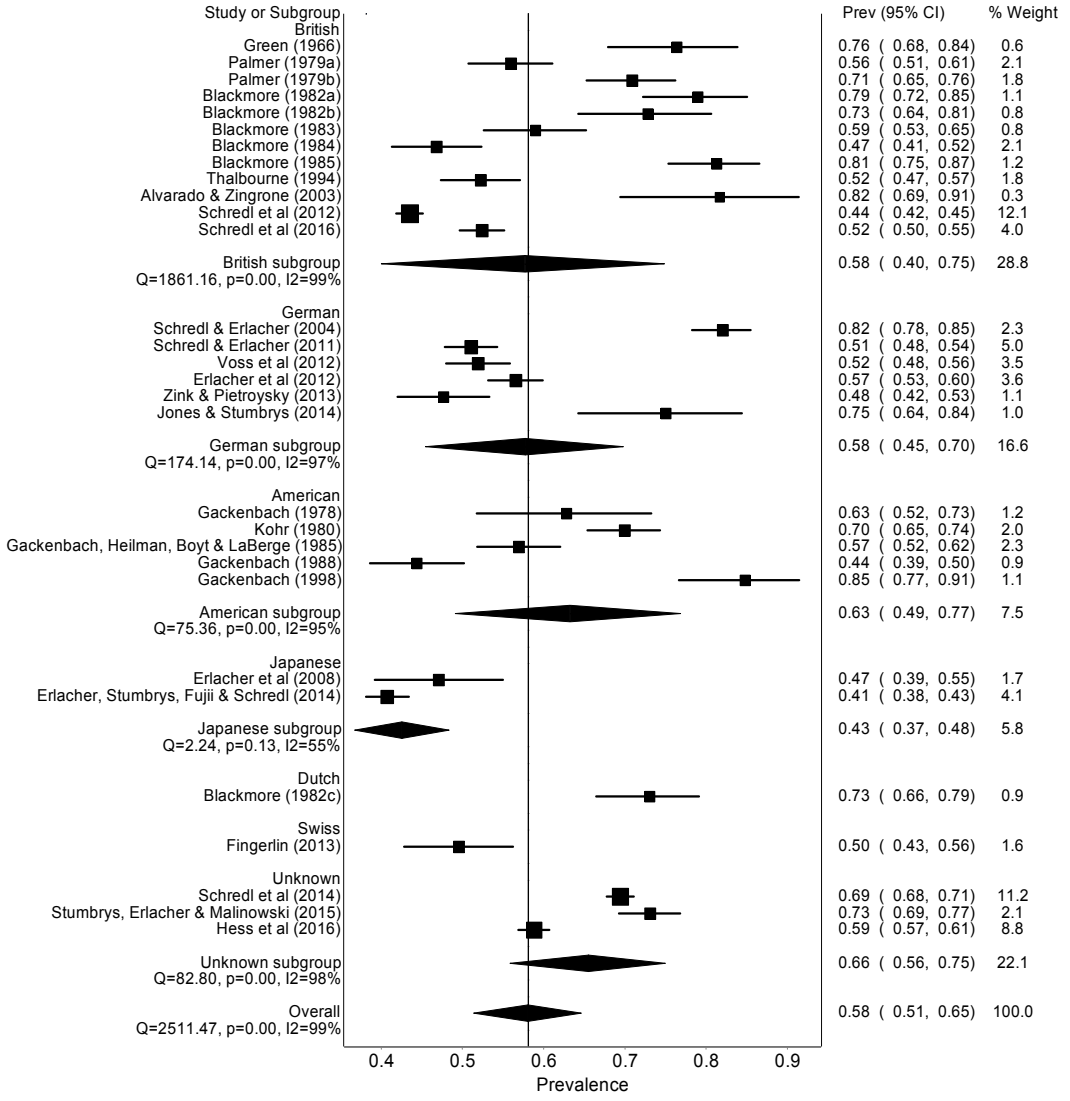


3.3. *Nationality Moderator Analysis*

Moderator analysis organising the sample estimates by participant nationality (Figure 4) showed British samples provide the largest weight to the final model (30.5%) and 5 of the 9 estimates (Alvarado & Zingrone, 2003; Blackmore, 1982a, 1982b, 1985; Green, 1966) are above the pooled estimate. However due to methodological quality and sample size these studies are weighted as the smallest individual British contributors to the model estimate. Overall the British samples pooled estimate is lower (51%, 95% CI [36% - 66%]) than the model pooled estimate (58%. 95% CI [51%-65%]) and with a wider confidence interval due to the subgroup having the highest heterogeneity ($Q = 297.42$, $p < .001$, $I^2 = 97\%$) suggesting methodological quality and sample characteristics are most different for this nationality. Of the seven studies in the German sub-group, the three most weighted studies demonstrate substantial overlap with one another (Erlacher et al., 2012; Schredl & Erlacher, 2011; Voss et al., 2012). Japanese samples are the only homogeneous sub-group ($Q = 2.24$, $p= .13$, $I^2 = 55\%$) their group estimate is also the largest observed deviation from the model estimate, being lower than the model by 15% (43%, 95% CI [37% - 48%]). Overall the two Japanese samples were the only

divergence from the pooled estimate on the basis of participant nationality, though their influence on the final model is small (7% weight) suggesting that no great effect of systematic bias by nationality on the final prevalence estimate is observed.

Figure 4: Quality effects moderator analysis for lucid dreaming prevalence by participant Nationality



3.4. *Participant Characteristic Moderator Analysis*

The next moderator analysis organises estimates by dominant participant characteristics (Figure 5). All moderator groupings contain significant heterogeneity, with student sample estimates making up the largest sub-group with a total of 13 out of 29 studies. The majority of higher estimates are found within this group (n = 7). Representative samples contribute the largest weight to the model, from five studies and have the second lowest heterogeneity compared to other groups. Children are the

second largest contributor to the model estimate, although only comprising two studies (Schredl et al., 2012; Voss et al., 2012) a combination of large samples and good methodological quality ratings account for this. The children studies group estimate (45%) is the only divergence from the model estimate of 58% however there is still an overlap of 95% confidence intervals between the two.

Despite intra-group heterogeneity, only interest group study point estimates consistently deviated from the overall model estimate. As these studies include individuals with a marked interest in lucid dreams, and consistently presented higher estimates, these were removed resulting in a reduction in the remaining significant heterogeneity (Q = 790.9, p= <.001, I^2 = 97%) resulting in an overall pooled estimate (Figure 6) of 55% [49%, 62%] for lucid dreaming prevalence, contributed from the remaining 27 studies included within the final model.

Figure 5: Quality effects moderator analysis for lucid dreaming prevalence by participant characteristics

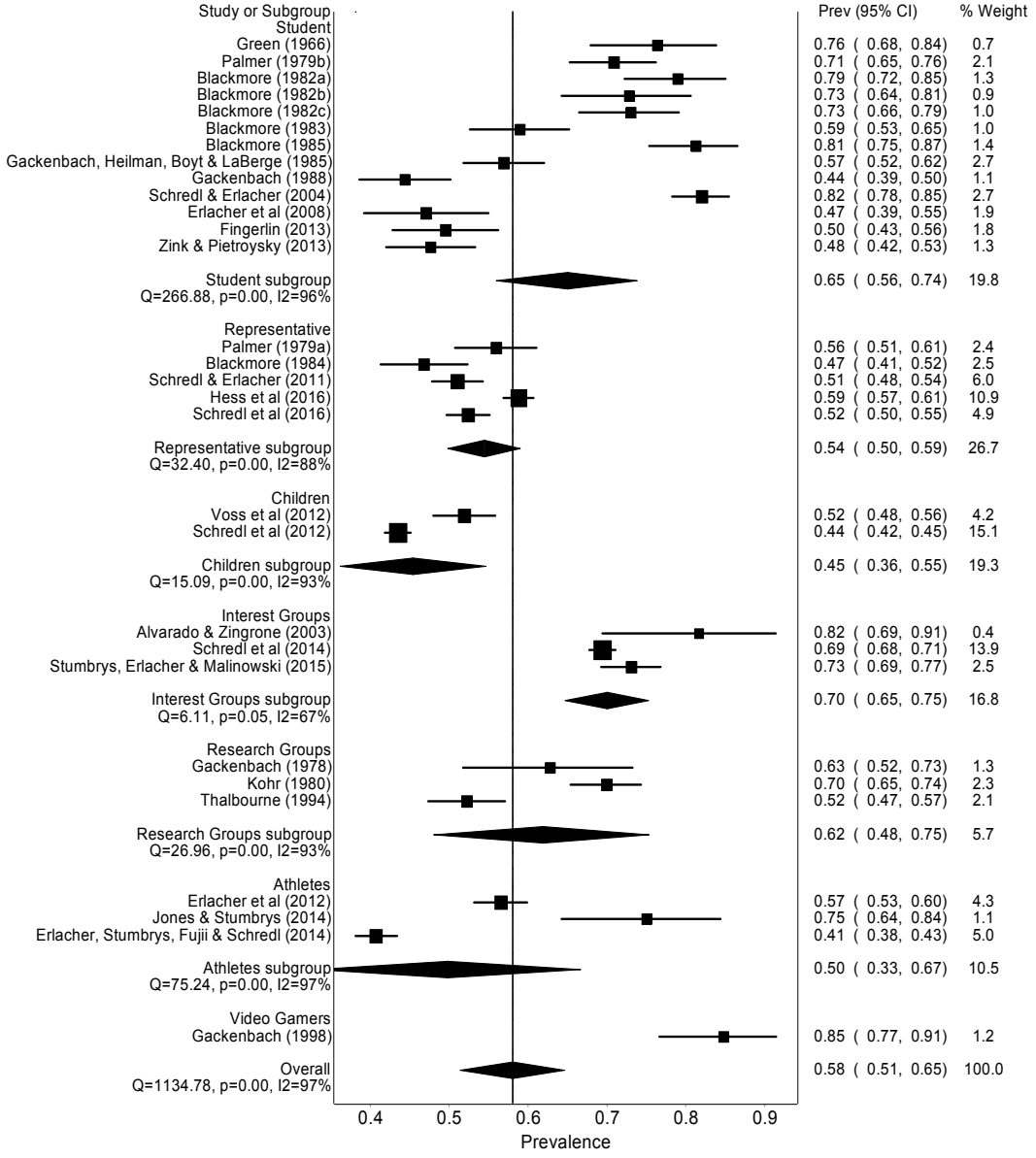
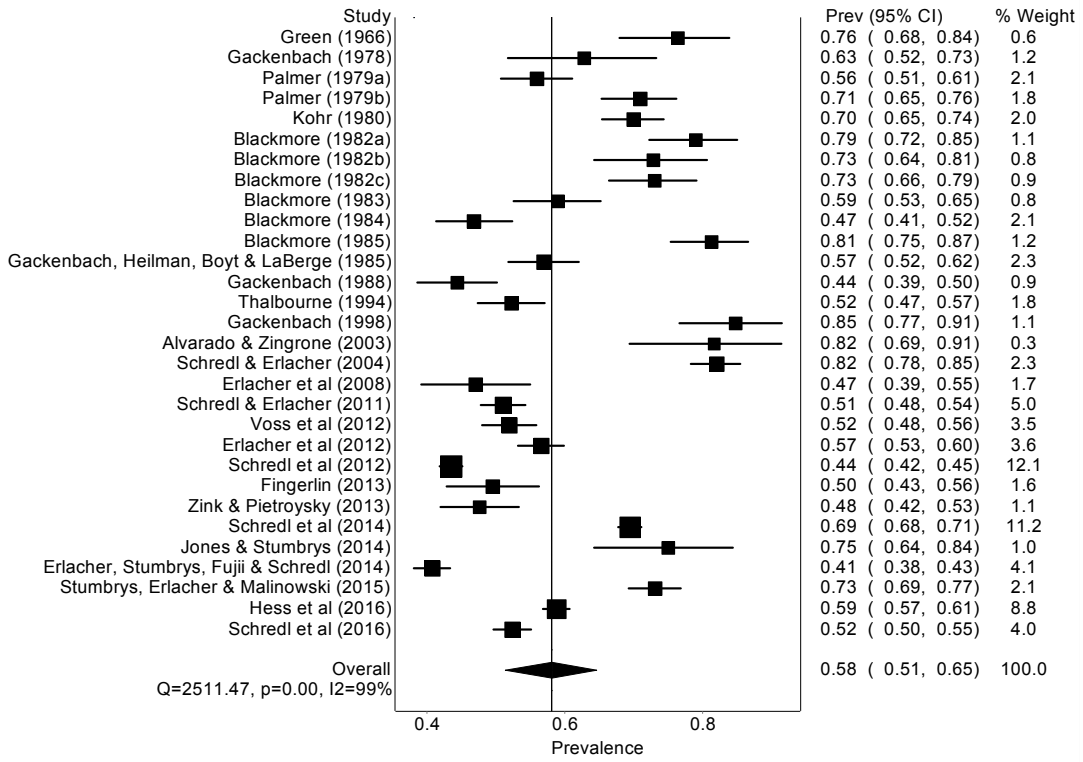


Figure 6: Final quality effects forest plot of lucid dreaming prevalence



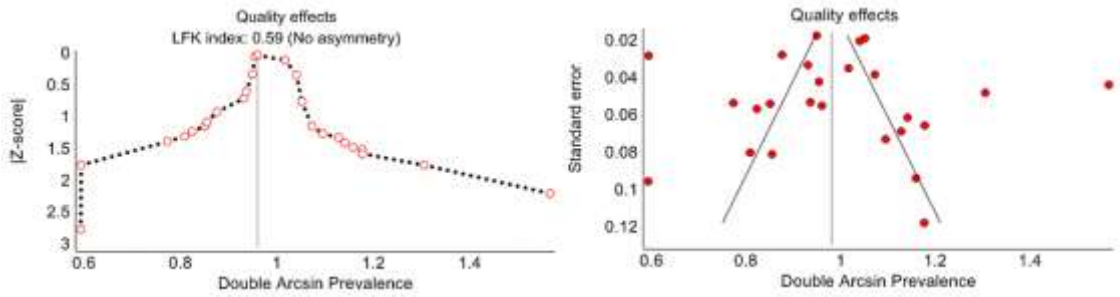
3.5. *Frequent Lucid Dreaming*

Frequent lucid dreaming (one or more lucid dreams per month) rates were reported by 25 of the 34 studies included within the prevalence analysis, with study estimates ranging from 8% to 50%. Studies included in the analysis of frequent lucid dreamers are reported in Table 1. An initial pooled estimate of 22%, 95% C.I. [19%, 27%] was calculated, with significant heterogeneity observed in the model ($Q = 553.99$, p = <.001, $I^2 = 96\%$).

3.5.1. *Publication Bias*

There was no evidence of asymmetry for the frequent lucid dreamer study estimates, with both the Doi and funnel plots (Figure 7) showing symmetry amongst estimates. With an LFK index score of +.59 this indicates no evidence of publication bias for estimates of frequent lucid dreaming, despite the existence of significant heterogeneity.

Figure 7: Doi & Funnel plots of frequent lucid dreaming estimates.



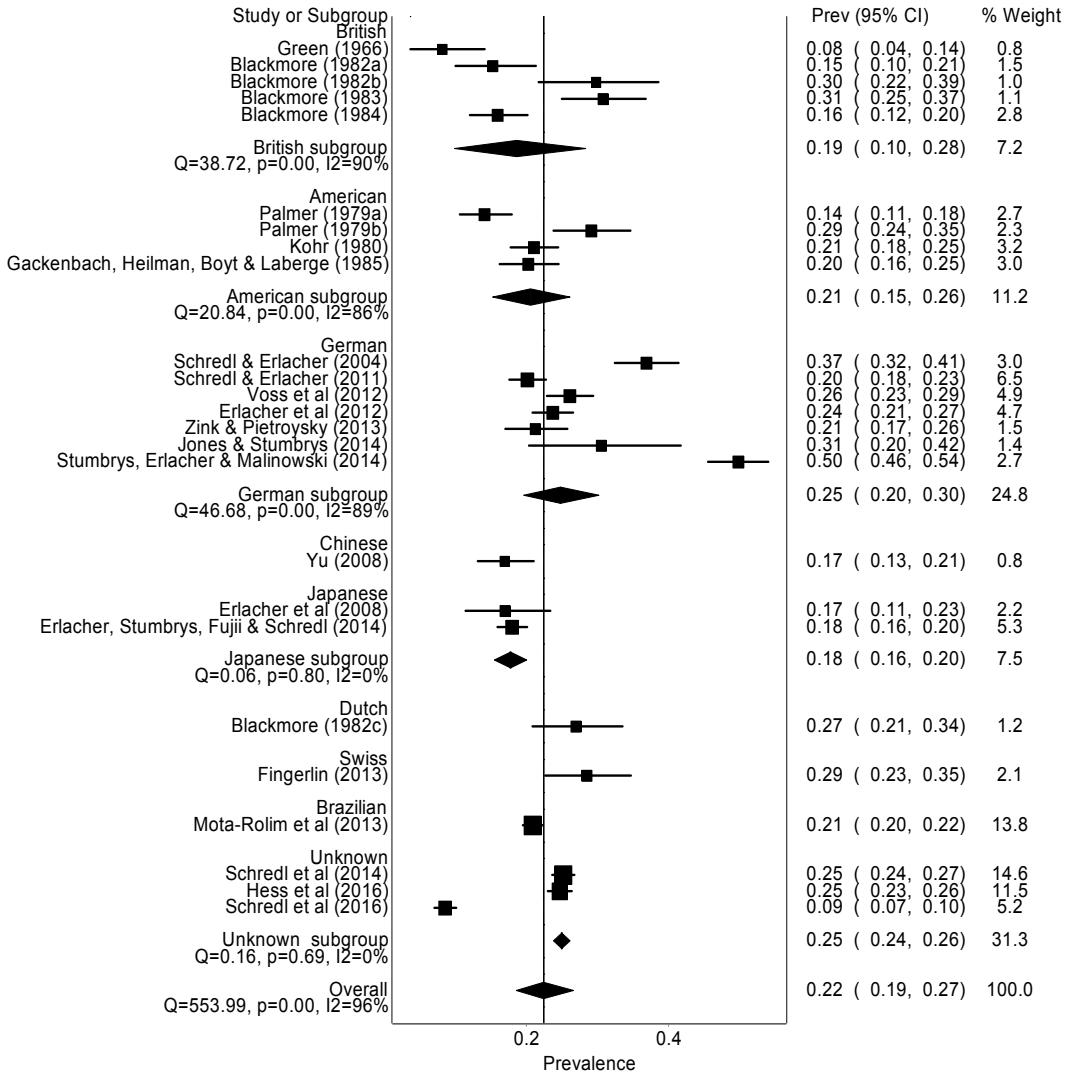
A sensitivity analysis was performed to identify these sources of heterogeneity for which two papers were identified as being primary sources (Schredl et al., 2016; Stumbrys, Erlacher & Malinowski, 2014). With these studies removed, a large reduction in heterogeneity was observed, despite remaining significant (Q = 178.2, p <.001, I^2 = 88%). This removal lowered the pooled estimate and made its interval estimate more precise (23%, 95% C.I. [20%, 25%]). Any further moderator analysis were conducted with these two studies omitted.

3.6. *Frequent Lucid Dreaming: Moderator Analyses*

Moderator analysis investigating researcher/research group showed no evidence of systematic bias; the independent study group estimate of 22%, 95% C.I. [18%, 26%] was 1% below the overall model estimate and with slightly wider confidence intervals.

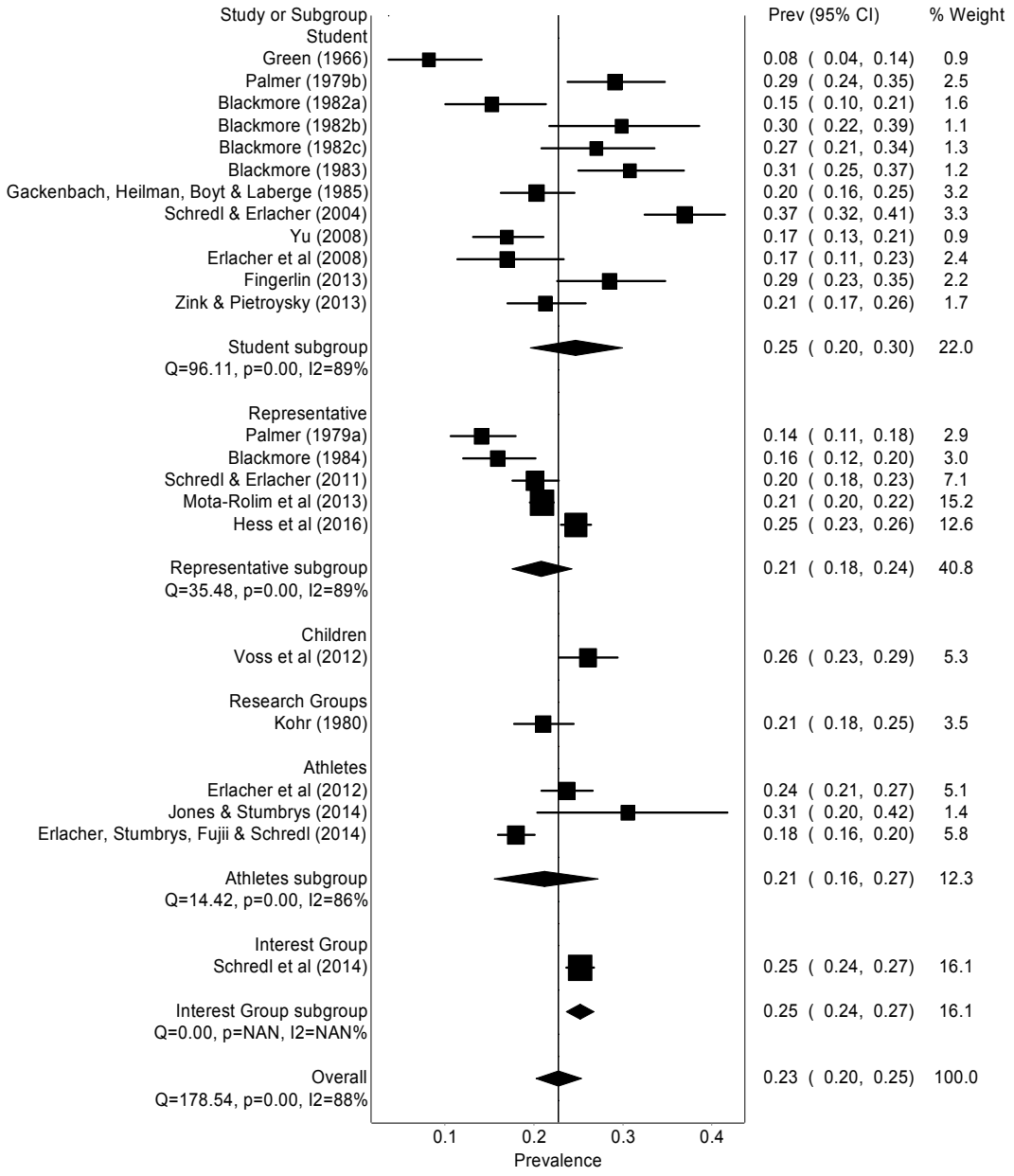
For participant nationality as moderator variable, every nationality (Figure 8) except single Dutch and Swiss samples overlap with the model estimate, suggesting no systematic differences in frequent lucid dreaming for participant nationality.

Figure 8: Quality effects moderator analysis for frequent lucid dreamers by participant nationality.



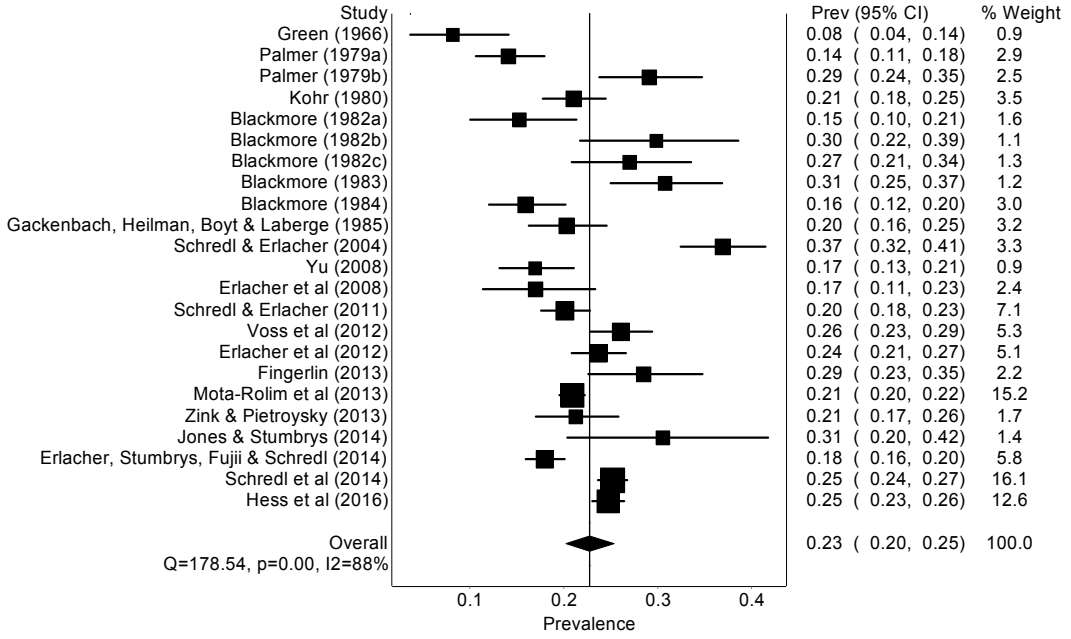
For the participant characteristic moderator analysis (Figure 9) the largest weight is contributed by studies utilising student samples (48.02%). The children sub-group diverge the furthest from the model estimate, with a moderator group estimate of 26%, 95% C.I. [23%, 29%]. Despite this and the lack of homogeneity within all sub groups overall participant characteristics do not substantially contribute to the heterogeneity observed within the model.

Figure 9: Quality effects moderator analysis for frequent lucid dreamers by participant characteristic.



None of the three moderator analyses exposed obvious sources of the remaining heterogeneity, thus all 22 studies retained following sensitivity analysis are included in the final model estimate for frequent lucid dreaming, shown in Figure 10.

Figure 10: Final quality effects analysis forest plot of frequent lucid dreaming



4. Discussion

Our quality effects meta-analysis shows the proportion of individuals who have experienced at least one lucid dream in their lifetime is 55% [49%, 62%] and that 23% [20%, 25%] report experiencing lucid dreams once a month or more. Despite the existence of heterogeneity study asymmetry was not a large issue for both lucid dreaming prevalence and frequent lucid dreamer analyses. Greater confidence can be had in the estimates provided by the frequent lucid dreamer analysis due to their consistency, though heterogeneity is still an issue it is much more widespread for prevalence estimates and thus our conclusions must be more cautious.

The final estimates we have presented are similar to those reported by Snyder and Gackenbach (1988) in their narrative review (58% and 21% respectively) suggesting there has been little change to reported lucid dreaming incidence rates over the last three decades and increases confidence in these estimates being an accurate reflection of lucid dreaming incidence in the population. If so, then the incidence of frequent lucid dreamers in the population is twice that of left-handedness (McManus, 2009) demonstrating that lucid dreams are indeed a frequent experience for many people; it also highlights the necessity for further research to identify what differentiates these individuals from those who infrequently or never experience lucid dreams. That 55% of the population has experienced at least one lucid dream in their lifetime suggests the capacity for lucid dreaming prevalence is widespread; an understanding of the underlying differences between these two groups may lead towards many more individuals experiencing lucidity on a more frequent basis in the future. This will greatly benefit research and improve understanding by allowing larger samples for research studies looking into the experience of lucid dreaming and exploring its potential practical applications such as its use as a psychological tool for overcoming phobias (LaBerge & Rheingold, 1990) developing the ability to control and overcome nightmares (Spoormaker, van den Bout & Meijer, 2003; Zadra & Phil, 1997) or as a psychophysiological tool for the refinement of motor-skills (Erlacher & Schredl, 2010; Stumbrys, Erlacher & Schredl, 2016).

In exploring the sources of heterogeneity, for participant nationality all group estimates were in line with the model estimate apart from the lower values presented by two homogeneous studies using Japanese samples (Erlacher et al., 2008; Erlacher et al., 2014) both of which have comparably good methodological quality index (Qi) ratings (see Table 1). Given the small number of studies included in this group, it remains to be seen whether this represents a real difference for lucidity rates in Japan. Notwithstanding this subgroup, frequent lucid dreaming estimates for different nationalities demonstrated a consistent pattern, indicating that overall nationality does not appear to be a significant influencing factor in lucid dreaming incidence.

Similarly, the moderator analysis for researcher/research group demonstrates no overall systematic biases, indicating that violations of the independence assumption were unlikely to be consequential in the overall estimates arrived at.

The current study also highlights useful insights into the incidence of lucid dreaming for different participant types and may help inform future theory generation or refinement for both the how and why of lucid dreaming.

The maturation hypothesis claims that studies utilising child and adolescent samples would show higher reported prevalence rates and have a higher proportion of frequent lucid dreamers than adult samples. This was supported for frequent lucid dreaming but not for prevalence where child and adolescent sample estimates were *lower* than adult groups. This implies that as people age they are increasingly more likely to report having experienced spontaneous lucid dreams. Indeed Voss et al. (2012) reports that prevalence rates increased steadily with age, and were highest (70%) for the oldest in their sample (18 and 19 year olds) similar trends were also demonstrated by Schredl et al. (2012).

For frequent lucid dreaming, the estimate contributed by Voss et al. (2012) is higher than the final model estimate in line with the maturation hypothesis; this is also supported by student samples overall providing a higher pooled estimate at 25%. However, student studies did not fare well in terms of methodological quality (table 1), in part reflecting the fact that the majority of higher estimate studies were published prior to the methodological recommendations proposed by Snyder & Gackenbach (1988). Later research utilising some of these controls on the whole show lower estimates for student samples, suggesting that rates of lucid dreaming may steadily increase throughout adolescence and plateau at the prevalence rates reflective of those seen in representative samples. Further research is needed to ascertain if estimates provided by adolescent and student samples are methodological artefacts or reflect real differences which may be attributable to age.

Lucid dreaming prevalence estimates were also at the higher end of the distribution for interest groups (70%) and video-gamers (85%). The former finding is unsurprising given the potential for tautology, with members of special interest groups being members potentially due to experiencing a lucid dream which may have occurred to them spontaneously and for which they join the group in pursuit of an explanation for their experience. Also, such groups can provide a forum that encourages attempts to induce lucidity and so can become self-fulfilling. The latter estimate from the video-gamer sample is above the model estimate and all other participant characteristic categories, in line with is expected by Gackenbach's hypothesis (Gackenbach, 2006; Gackenbach & Hunt, 2014).

Aside from student samples, estimates from athletes were the most heterogeneous; though with only three studies it is unclear if incidence rates for athletes different from other sample types. The estimate from Erlacher et al. (2014) is below the overall model estimate, however this sample comprised of Japanese athletes, so may be

confounded by nationality differences, as Japan were the only nationality to have a lower group estimate than the pooled model estimate for lucid dreaming prevalence estimates. The other two athlete estimates suggest they are either as likely as the general population to experience a spontaneous lucid dream or more so. This at present does not support the proposition that athletes utilise lucid dreaming more regularly due to potential practical benefits from a motor-skill enhancement effect. Evidence from the frequent lucid dreaming estimates suggests that athletes who experience frequent lucid dreams are proportionate to representative samples (21%) suggesting an increased use of mental imagery in waking life (Cumming & Hall, 2002) alone does not lead to a greater propensity for frequent lucid dreams. In light of the inconsistency of estimates for this sample type further studies are required in order to determine if the proposed benefits suggested by Erlacher & Schredl (2008) and Tholey (1990) of lucid dreaming for motor-action, translates into athlete groups more likely to experience lucid dreams and experience them in a greater frequency when compared to representative samples.

Regarding study methodology a key finding from this paper is the average Qi rating of studies presented as .46, suggesting lucid dreaming incidence methodologies can be improved in future research. It is recommended that researchers wishing to investigate lucid dreaming incidence ensure the necessary methodological steps are in place to increase confidence in their findings. These steps include; the provision of a clear definition of what constitutes a lucid dream, with no stipulation that dream control is a necessity (however additional information on the degree of disassociation, control and insight experienced would be useful); this definition should be supplemented by an example dream narrative and a request for a written account of one of their own experienced, which should be judged for characteristic signs that demonstrate the dream account is clearly of a lucid dream, questionable accounts should not be qualified. In self-report studies, questions regarding lucid dream frequency should provide no less than a 7 point response scale. Here it is recommended a standardised measurement protocol is utilised so direct comparisons across samples can be made. Due to providing the respondent with eight options the scale presented by Erlacher & Schredl (2004) was the most sensitive measure of frequent lucid dreaming we reviewed. By measuring the frequency of lucidity from less than once a year up to once a week or more it clearly determines the frequency of lucid dream experiences, unlike some other scales which have been used (e.g. Blackmore, 1983, 1985; Mota-Rolim et al., 2013) Furthermore Erlacher and Schredl's scale has been shown by Stumbrys, Erlacher and Schredl (2013) to have good test-retest reliability $r = .89$ ($p < .001$) Therefore it is recommended here over other previously adopted self-report scales of lucid dreaming frequency for utilisation in future research in this area. Finally, a consideration of potential confounding variables is recommended as in the procedure presented by Voss et al. (2012) in order to control for issues of suggestibility and social desirability in self report studies.

It is further recommended all data regarding suspected relevant sample characteristics to be recorded alongside incidence measures to aid in the identification of sources of variability amongst estimates. By adhering to these recommendations, researchers can be confident that the data gathered is a valid reflection of lucid dreaming incidence in the population.

The quality effects meta-analysis method we utilised is a new technique which was initially developed for epidemiological research (Doi & Thalib, 2008). In this paper we have shown it can be usefully applied to other topic areas in place of a random of fixed effect analysis, particularly where clearly identifiable differences exist in study methodological quality, in order to provide additional control for this source of potential

bias. The degree to which this is effectively controlled rests on the development of an effective quality assessment scale, the scale developed for this study (LDIM-Qi) attempts to incorporate all methodological considerations which have been highlighted as problematic in the literature. The scale is scored in a way that reduces subjective judgement on the part of the assessor, with many items being binary decisions. Thus we believe it is an effective and reliable tool for measuring the methodological quality of studies in this area.

A limitation of this study is that despite attempts to be as inclusive as possible it is possible that papers may have been missed by our search for through the literature. Additionally, we were unable to gain contact with several primary authors, despite emails being sent no replies were received, thus it is likely that additional grey literature exists which was not included within this paper.

Furthermore, the sources of heterogeneity across both analyses were not effectively identified, though it seems interest group estimates and studies that do not focus on lucid dreaming specifically are certainly contributors to the observed heterogeneity. The findings from this analysis do go some way to informing us what these sources are not and also correct the model estimates in light of methodological quality, where the tendency appeared for poorer quality studies to provide higher incidence estimates.

In conclusion the findings imply the original estimates presented by Snyder & Gackenbach (1988) were not influenced by the kinds of bias this analysis controls for and thus this study lends support to the earlier conclusions while providing more robust point and interval estimates by taking study methodological quality and potential moderator variables into account. Overall this review can serve to inform future research by contributing to the confidence that can be had in our knowledge of how common lucid dreaming is and how many of the population experience them on a frequent basis of once a month or more.

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References

Alexander, C. N., Cranson, R. W., Boyer, R., & Orme-Johnson, D. W. (1986). Transcendental consciousness: A fourth state of consciousness beyond sleep, dreaming and waking. In J. Gackenbach (Ed.) *Sourcebook on sleep and dreams*, 282-315. New York: Garland.

Alvarado, C. S., & Zingrone, N. L. (2003). Exploring the factors relating to the after-effects of out-of-the body experiences. *Journal of the Society for Psychical Research*, 67, 161-183.*

Alvarado, C. S., & Zingrone, N. L. (2007). Interrelationships of Parapsychological Experiences, Dream Recall, and Lucid Dreams in a Survey with Predominantly Spanish Participants. *Imagination, Cognition and Personality*, 27, 1, 63-69.*

Banov, M., Kongsved, S. M., Bech, P., & Hjollund, N. H. (2009). Reliability of short form-36 in an internet and a pen-and-paper version. *Informatics for Health and Social Care*, 34, 53-58.

Barendregt, J. J., Doi, S. A., Lee, Y. Y., Norman, R. E. & Vos, T. (2013). Meta-analysis of Prevalence. *Journal of Epidemiology and Community Health*, 67, 974–978.

Benfield, J. A. & Szlemko, W. J. (2006). Internet-based data collection: Promises and realities. *Journal of Research Practice*, 2, 2, Article D1. Retrieved [18/03/2016] from, http://jrp.icaap.org/index.php/jrp/article/view/30/51

Berrens, R. P., Bohara, A. K., Jenkins-Smith, H., Silva, C., & Weimer, D. L. (2003). The advent of Internet surveys for political research: A comparison of telephone and Internet samples. *Political Analysis,* 1, 1, 1-22.

Blackmore, S. J. (1982a, b). Out-of-body experiences, lucid dreams and imagery: Two surveys. *The Journal of the American Society for Psychical Research*. 76, 4, 301-317.*

Blackmore, S. J. (1982c). Have you ever had an OBE? The wording of the question. *Journal of the Society for Psychical Research*, 51, 292-302.*

Blackmore, S. J. (1983). Birth and the OBE: An Unhelpful Analogy. *Journal of the American Society for Psychical Research,* 77, 229-238.*

Blackmore, S. J. (1984). A postal survey of OBEs and other experiences. *Journal of the Society for Psychical Research*, 52, 225–244.*

Blackmore, S. J. (1985). Viewpoints in imagery, memory and the near-death experience. *International Imagery Bulletin*, 2, 16.*

Calleja, G. (2007). Digital game involvement: A conceptual model. *Games and Culture*, 2, 236-260.

Condron, B. (1994). *The dreamer's dictionary.* Windyville, Missouri: SOM Publishing

Chang, C. (1963). *Teachings of Tibetan yoga*. New Hyde Park, N. Y: University books.

Crust, L. (2007). Mental toughness in sport: A review. *International Journal of Sport and Exercise Psychology*, 5, 3, 270-290.

Cumming, G. (2011). Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis. Routledge

Cumming, J., & Hall, C. (2002). Athletes' use of imagery in the off-season. *The Sport Psychologist*, 16, 160-172.

Deeks, J. J., Dinnes, J., D'Amico, R., Sowden, A. J., Sakarovich, C., Song, F., Petticrew, M., & Altman, D. G. (2003). Evaluating non-randomised intervention studies. *Health Technology Assessment*, 7, 27, 1-173.

Doi, S. A., & Thalib, L. A. (2008). A quality-effects model for meta-analysis. *Epidemiology*, 19, 94–100.

Doi, S. A., & Thalib, L. A. (2009). An alternative quality adjustor for the quality effects model for meta-analysis. *Epidemiology*, 20, 2, 314

Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health*, 52, 377-384.

Erlacher, D., & Schredl, M. (2008). Do REM (lucid) dreamed and executed actions share the same neural substrate? *International Journal of Dream Research*, 1, 1, 7-14.

Erlacher, D., & Schredl, M. (2010). Practicing a Motor Task in a Lucid Dream Enhances Subsequent Performance: A Pilot Study. *The Sports Psychologist*, 24, 2, 157-167.

Erlacher, D., Schredl, M., Watanabe, T., Yamana, J., & Gantzert, F. (2008). The Incidence of Lucid Dreaming within a Japanese University Student Sample. *International Journal of Dream Research*, 2, 39-43.*

Erlacher, D., Stumbrys, T., Fujii, M., & Schredl, M. (2014). Lucid dream practice in German and Japanese athletes: A questionnaire study. Conference presentation at the 6th SGS-meeting 13.-14. February 2014, Fribourg.*

Erlacher D., Stumbrys T., & Schredl, M. (2012). Frequency of lucid dreams and lucid dream practice in German athletes. *Imagination, Cognition and Personality*, 31, 237–246.*

Fingerlin, T. (2013). Incidence and frequency of lucid dreams in a Swiss junior college student sample. *International Journal of Dream Research*, 6, 2, 57–59.*

Gackenbach, J. I. (1979). *A personality and cognitive style analysis of lucid dreaming.* (Un-published doctoral dissertation). Virginia Commonwealth University. America. *

Gackenbach, J. I. (1982). Balance and lucid dreaming ability: A suggested relationship, *Lucidity Letter,* 1, 2, 7.

Gackenbach, J. I. (1988). Personality differences between individuals varying in lucid dreaming frequency. *Journal of Communication Therapy*, 4, 49-63.*

Gackenbach, J. I. (1990). Women and meditators as gifted lucid dreamers. In S. Krippner (Ed.). *Dreamtime and dreamwork: Decoding the language of the night,* 244-251. Los Angeles: Jeremy P. Tarcher

Gackenbach, J. I. (1998). Unpublished manuscript*

Gackenbach, J. I. (2006). Video game play and lucid dreams: implications for the development of consciousness. *Dreaming*, 16, 96-110.

Gackenbach, J. I. (2009). Video game play and consciousness development: A replication and extension. *International Journal of Dream Research*, 2, 1, 3-11.

Gackenbach, J. I., Cranson, R., & Alexander, C. (1986). Lucid dreaming, witnessing, and Transcendental Meditation: A developmental relationship. *Lucidity Letter*, 5, 34–41.

Gackenbach, J. I., & Bosveld, J. (1989). *Control your dreams*. New York: Harper & Row

Gackenbach, J. I., Heilman, N., Boyt, S. & LaBerge, S. (1985). The relationship between field independence and lucid dreaming ability. *Journal of Mental Imagery*, 2, 1, 9–20.*

Gackenbach, J. I., & Hunt, H. T. (2014). A deeper inquiry into the association between lucid dreams and video game play. In R. Hurd & K. Bulkeley (Eds.) *Lucid dreaming: New perspectives on consciousness in sleep* (Vol. 1, pp. 231-253). Praeger: ABC-CLIO

Gackenbach, J. I., & Kuruvilla, B. (2008). The relationship between video game play and threat simulation dreams. *Dreaming*, 18, 4, 236-256.

Gackenbach, J. I., Prill, S., & Westrom, P. (1983). The relationship of the lucid dreaming ability to mental imgery experiences and skills. *Lucidity Letter*, 2, 4, 4-6.

Gackenbach, J.I., Snyder, T.J., Rokes, L., & Sachau, D. (1986). Relationship of the lucid dreaming ability to vestibular sensitivity as measured by caloric nystagmus. *Cognition and Dream Research: Special Issue of the Journal of Mind and Behavior*, 7, 2, 3, 277-298.

Gillespie, G. (1984). Can we distinguish between lucid dreams and dreaming awareness dreams? *Lucidity Letter*, 3, 2, 9-11.

Glass, G. V. (1976). Primary, secondary and meta-analysis of research. *Educational Researcher*, 5, 10, 3-8.

Green, C. E. (1966). Spontaneous "paranormal" experiences in relation to sex and academic background. *Journal of the Society for Psychical Research*, 43, 357-363.*

Green, C. E., & McCreery, C. (1994). *Lucid dreaming: The paradox of consciousness during sleep*. Routledge

Greenfield, P. M., Brannon, C., & Lohr, D. (1996). Two-dimensional representation of movement through three-dimensional space: The role of video game expertise. In P. M. Greenfield & R. R. Cocking (Eds.), *Interacting with video: Advances in applied developmental psychology*, 11, 169-185. Norwood, NJ: Ablex

Hassan, E. (2005). Recall bias can be a threat to retrospective and prospective designs. *The Internet Journal of Epidemiology*, 3, 2.

Hardy, L., Jones, G., & Gould, D. (1996). *Understanding psychological preparation for sport: Theory and practice of elite performers*. Wiley: Chichester.

Hearne, K. M. T. (1978). *Lucid-dreams: an electrophysiological and psychological study*. (Unpublished doctoral dissertation). Hull University. England.

Hearne, K. M. T. (1983). Features of lucid dreams: Questionnaire data and content analysis. *Journal of Lucid Dream Research*. 1, 1, 3-20.

Hess, G., Schredl, M., & Göritz, A. S. (2016). Lucid dreaming frequency and the Big Five personality factors. Unpublished Manuscript.

Hunt, H.T. (1987). Lucidity as a meditative state. *Lucidity Letter*, 6, 2, 105–112

Hunt, H.T. (1989). *The Multiplicity of Dreams.* New Haven: Yale University Press.

Hunt, H.T. (1991). Lucid dreaming as a meditative state: Some evidence from long-term meditators in relation to the cognitive-psychological bases of transpersonal phenomena. In J. I. Gackenbach & A. A. Sheikh (Eds.), *Dream images: A call to mental arms*, 265-285. Amityville, New York: Baywood.

Hunt, H.T. & McLeod, B. (1984*). Lucid dreaming as a meditative state: Some evidence from long term meditators in relation to the cognitive-psychological bases of transpersonal phenomena.* Paper presented at the annual meeting of the Eastern Psychological Association, Baltimore, MD.

IBM Corp. (2013). IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp

Jones, S. M. R., & Stumbrys, T. (2014). Mental health, physical self and lucid dreaming: A correlational study in sport students. *International Journal of Dream Research, 7*, 1, 54-60.

Khalaf, M. M., Thalib, L., & Doi, S. A. R. (2011). Combining heterogenous studies using the random-effects model is a mistake and leads to inconclusive meta-analyses. *Journal of Clinical Epidemiology*, 64, 2,119-23.

Kohr, R. L. (1980). A survey of psi experiences among members of a special population. The *Journal of the American Society for Psychical Research*, 74, 295–411.*

Kueny, S. R. (1985). An examination of auditory cueing in REM sleep for the induction of lucid dreams. Unpublished doctoral dissertation. Pacific graduate school of psychology.

Kühle, L. (2015). Insight: what is it, exactly? - A commentary on Ursula Voss & Allan Hobson. In T. Metzinger & J. M. Windt (Eds). *Open MIND*: 38, Frankfurt am Main, MIND Group.

LaBerge, S. (1980). *Lucid dreaming: An exploratory study of consciousness during sleep*. (Unpublished doctoral dissertation). Stanford University. America.

LaBerge, S. (1985). Lucid dreaming: The power of being awake and aware in your dreams. New York: Simon and Schuster.

Laughlin, C. D. (2011). *Communing with the gods*: *Consciousness, culture and the dreaming brain.* Daily Grail Publishing

LaBerge, S., & Rheingold, H. (1990). *Exploring the world of lucid dreaming*. Ballantine Books.

Levitan, L., & LaBerge, S. (1991). Other Worlds: Out-of-body experiences and lucid dreams. *Nightlight,* 3, 2-3.

Lewis, I. M., Watson, B. C., & White, K. M. (2009). Internet versus paper-and-pencil survey methods in psychological experiments: equivalence testing of participant responses to health-related messages. *Australian Journal of Psychology*, 61, 2, 107-116.

Lohmann, R. I., & Dahl, S. A. P. (2014). Cultural contingency and the varieties of lucid dreaming. In R. Hurd

& K. Bulkeley (Eds.) *Lucid dreaming: New perspectives on consciousness in sleep* (Vol. 2, pp. 23-43). Praeger: ABC-CLIO

Lozano, L. M., García-cueto, E., & Muñiz, J. (2008). Effect of the number of response categories on the reliability and validity of rating scales. *Methodology: European Journal of Research Methods for the Behavioural and Social Sciences*, 4, 2, 73-79.

Malle, B. F. (2006). The actor-observer asymmetry in attribution: A (surprising) meta-analysis. *Psychological Bulletin*, 132, 6, 895-919.

Maynard, A. E., Subrahmanyam, K., & Greenfield, P. M. (2005). Technology and the development of intelligence: From the loom to the computer. In R. J. Sternberg & D. D. Preiss (Eds.), *Intelligence and technology: The impact of tools on the nature and development of human abilities*, 29-53. Mahwah, NJ: Erlbaum.

McManus, I. C. (2009). The history and geography of human handedness. In I. E. C. Sommer & R. S. Kahn (Eds). *Language lateralization and psychosis.* Cambridge University Press

Mota-Rolim, S. A., Targino, Ze. H., Souza, B. C., Blanco, W., Araujo, J. F., & Ribeiro, S. (2013). Dream characteristics in a Brazilian sample: an online survey focusing on lucid dreaming. *Frontiers in Human Neuroscience*, 7, 1-11.*

Nielsen, T. A., Zadra, A. L., Simard, V., Saucier, S., Stenstrom, P., Smith, C., & Kuiken, D. (2003). The typical dreams of Canadian university students. *Dreaming*, 13, 4, 211-235.

Pagal, J. F. (2014). Lucid dreaming as sleep meditation. In R. Hurd & K. Bulkeley (Eds.) *Lucid dreaming: New perspectives on consciousness in sleep* (Vol. 1, pp. 63-76). Praeger: ABC-CLIO

Palmer, J. (1979). A community mail survey of psychic experiences. *Journal of the American Society for Psychical Research*, 73, 221-251.*

Preston, J. (2007). From mediated environments to the development of consciousness In J. I. Gackenbach (Ed.), *Psychology and the internet*, 255-291. San Diego: Academic Press.

Rogo, D. S. (1978). Mind beyond the body. Penguin Books.

Rogo, D. S. (1985). Out-of-body experiences as lucid dreams: A critique. *Lucidity Letter*, 4, 2, 43-47.

Salley, R. D. (1986). Comments on the OBE/lucid dream controversy. *Lucidity Letter*, 5, 1, 47-57.

Schacter, D. L. (1999). The seven sins of memory: Insights from psychology and cognitive neuroscience. *American Psychology*, 54, 182-203.

Schädlich, M., & Erlacher, D. (2012). Applications of lucid dreams: An online study. *International Journal of Dream Research*, 5, 2, 134-138.

Schillewaert, N., & Meulemeester, P. (2005). Comparing response distributions of offline and online data collection methods. *International Journal of Market Research,* 47*,* 2, 163-178.

Schredl, M. (2003). Continuity between waking and dreaming: A proposal for a mathematical model. *Sleep and Hypnosis*, 5, 26-39.

Schredl, M. (2010). Dreaming and waking: Phenomenological and biological differences. *International Journal of Dream Research,* 3, 1, 46-48.

Schredl, M., Ciric, P., Gotz, S., & Wittmann, L. (2004). Typical dreams: Stability and gender differences. *The Journal of Psychology: Interdisciplinary and Applied*, 138, 6, 485-494.

Schredl, M., & Erlacher, D. (2004). Lucid dreaming frequency and personality. *Personality and Individual Differences*, 37, 1463-1473.*

Schredl, M., & Erlacher, D. (2011). Frequency of lucid dreaming in a representative German sample. *Perceptual and Motor Skills*, 111, 60-64.*

Schredl, M., Henley-Einion, J., & Blagrove, M. (2012). Lucid dreaming in children. *International Journal of Dream Research*, 5, 1, 94-98.*

Schredl, M., Henley-Einion, J., & Blagrove, M. (2016). Lucid dreaming and personality in children/adolescents and adults: The UK library study. Unpublished manuscript.*

Schredl, M., Berres, S., Klingauf, A., Schellhaas., & Göritz, A. S. (2014). The Mannheim Dream questionnaire (MADRE): Retest reliability, age and gender effects. *The International Journal of Dream Research,* 7, 2, 141-147.

Snyder, T., & Gackenbach, J. I. (1988). Individual differences associated with lucid dreaming. In S. LaBerge & J. I. Gackenbach (Eds.) *Conscious mind, sleeping brain: Perspectives on lucid dreaming*. Plenum Press

Sparrow, G. S. (1976). *Lucid dreaming: Dawning of the clear light*. Virginia Beach, VA: A.R.E. Press.

Stepansky, R., Holzinger, B., Schmeiser-Rieder, A., Saletu, B., Kunze, M., & Zeitlhofer, J. (1998). Austrian dream behavior: results of a representative population survey. *Dreaming*, 8, 23-30.*

Stumbrys, T., Erlacher, D., & Schredl, M. (2013). Reliability and stability of lucid dream and nightmare frequency scales. *International Journal of Dream Research*, 6, 2, 123-126.

Stumbrys, T., Erlacher, D., Johnson, M., & Schredl, M. (2014). The phenomenology of lucid dreaming: an online survey. *American Journal of Psychology*, 127, 2, 191-204.*

Stumbrys, T., Erlacher, D., & Malinowski, P. (2015). Meta-awareness during day and night: The relationship between mindfulness and lucid dreaming. *Imagination, Cognition and Personality*.*

Stumbrys, T., Erlacher, D., & Schredl, M. (2016). Effectiveness of motor practice in lucid dreams: a comparison with physical and mental practice. Journal of Sports Science, 34, 1, 27-34.

Tart, C. (1988). From spontaneous event to lucidity: a review of attempts to consciously control nocturnal dreaming. In J.I.Gackenbach and S. LaBerge (eds), Conscious mind, sleeping brain: Perspectives on lucid dreaming. New York: Plenum Press

Thalbourne, M. A. (1994). The SPR Centenary Census: II. The survey of beliefs and experiences. *Journal of the Society for Psychical Research*, 59, 420-431.*

Tholey, P. (1990). Applications of lucid dreaming in sports. *Lucidity Letter*, 9, 2, 6-17.

Triandis, H. C. (2002). Subjective culture. In W. J. Lonner., D. L. Dinnel., S. A. Hayes. & D. N. Sattler. (Eds.), Online Readings in Psychology and Culture, Center for Cross-Cultural Research, Western Washington University, Bellingham, Washington USA.

Van Eeden, F. (1913). A study of dreams. *Proceedings of the Society for Psychical Research*, 26, 431-461.

Vosylis, R., Malinauskiene, O., & Zukauskiene, R. (2012). Comparison of internet-based versus paper-and-pencil administered assessment of positive development indicators in adolescents' sample. *Psichologija,* 45, 7-21.

Voss, U., Frenzel, C., Koppehele-Gossel, J., & Hobson, J. A. (2012). Lucid dreaming: An age-dependent brain dissociation. *Journal of Sleep Research*, 21, 6, 634-642.*

Wangyal, T. (1998). *The Tibetan yogas of dream and sleep*. New York: Snow Lion Publications

Watson, D. (2001). Dissociations of the night: individual differences in sleep-related experiences and their relation to dissociation and schizotypy. *Journal of Abnormal Psychology*, 110, 526-535.

Wells, G. A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2014). The Newcastle-Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses. http://www.ohri.ca/programs/clinical_epidemiology/oxford htm 2009 [cited 2014 Nov 21]; Available from: URL:http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm

Yu, C. K. C. (2008). Dream Intensity Inventory and Chinese people's dream experience frequencies. *Dreaming*, 18, 2, 94-111.*

Zink, N., & Pietroysky, R. (2013). Relationship between lucid dreaming, creativity and dream characteristics. *International Journal of Dream Research*, 6, 2, 98-103.*

Appendix I

Example Lucid Dreaming Incidence Methodological Quality Scale (LDIM-Qi)

Reporting

1. Is the hypothesis/aim/objective of the study clearly described?

Yes	No
1	0

2. Were relevant details about the sample provided fully? (e.g. representativeness, sex, age)

Yes	Partially	No
2	1	0

3. Was the administration of the measurement protocol fully described?

Yes	Partially	No
2	1	0

Total for Reporting = /5

External Validity

4. Was the sample representative?

Yes	No
1	0

5. How was the sample obtained?

Random	Semi-Random	Not-stated/Self-selected/Other
2	1	0

Total for External Validity = /3

Internal Validity

6. Was a clear definition of lucidity provided to all participants?

Yes	No
1	**0**

7. Was the definition of a lucid dream focused on insight and meta-awareness within the dream state only or with the addition of control?

Broad Definition	Strict Definition (Control)	No Definition
2	1	0

8. Was an example lucid dream narrative provided to the participants?

Yes	No
1	0

9. Were the participants asked to recount a lucid dream experience of their own to demonstrate understanding?

Yes	No
1	0

10. Was the question asked of participants worded clearly?

Yes	No
1	0

11. Were measures taken to control for confounding factors? (Suggestibility/Social Desirability etc.)

Comprehensive	Partial	No
2	1	0

12. Response scale

7+ point clear scale	4+ point clear scale	three point, dichotomous or unclear scale
2	1	0

Total for Internal Validity = /10 *Total for scale = /18*