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The 1000 Most Cited Papers on Visible Nonverbal Behavior: A Bibliometric Analysis

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Abstract Using one of the key bibliometric methods, namely the index of citations, from a comprehensive multidisciplinary bibliographic electronic database, Web of Science, this article provides a circumscribed descriptive analysis of 1000 most-cited papers in the research field of visible nonverbal behavior. Using this method, we outline the most influential topics and research programs, and sketch the development of relevant features over the years. Topics include nonverbal behavior, facial expression, personal space, gesture, thin slices, and others, but exclude vocal or auditory cues. The results show that the 1000 most cited papers on visible nonverbal behavior emerged in the 1960s, and peaked in 2008. Revealing the strong interdisciplinary nature of the field, the 1000 papers come from 297 journals. Further, 33 journals had 7 or more papers, contributing to more than 50% ($n = 515$) of the 1000 most cited papers. The most cited paper (Whalen et al. in Emotion 1(1):70–83, 2001. https://doi.org/10.1037/0033-2909.111.2.256, a neuroscience paper) is cited 1341 times, and Paul Ekman has the highest number of papers (17) as first or last author. Results are compared with two other corpora of papers (i.e., a random sample control group and a current papers group) to provide a more thorough understanding of possible future directions in visible nonverbal behavior. Results differ from those that emerge from other citation indexes and are intended to give a flavor of key peer reviewed papers (excluding books and chapters) contributing to the development of scientific knowledge on visible nonverbal behavior.

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Introduction

Since Charles Darwin published *The Expression of the Emotions in Man and Animals* in 1872, researchers contribute to the research field of nonverbal communication, that is "communication effected by means other than words, assuming words are the verbal element" (Knapp et al. 2014, p. 8). Nonverbal communication notably includes communication through physical attributes, tone of voice, odors, visible nonverbal behavior, and even parts of the environment. These nonverbal cues serve different functions. For example, facial symmetry and body odors can influence mate choice (Rikowski and Grammer 1999), emotions are identifiable through distinct voice characteristics (Scherer 1995) and environmental attributes such as behavioral residue in an office or a room offer cues to assess the personality of its owner (Gosling et al. 2002). With regard to visible nonverbal behavior such as posture, gait, hand movements, personal space, and facial expressions, a plethora of peer reviewed papers were published in the last decades.

Unfortunately, visible nonverbal behavior is also the playing field of so-called experts who receive media exposure promoting self-help books and seminars where false beliefs and frivolous notions about nonverbal communication are promoted, even claiming that experimental research in nonverbal communication is disconnected from reality and serves little to no purpose in real life. However, thousands of peer reviewed papers on nonverbal communication not only address in a very pragmatic way real life issues, but also contribute to setting up evidence-based practices (Burgoon et al. 2010; Knapp et al. 2014; Moore et al. 2014). Moreover, researchers proactively draw the line between people's beliefs and actual relations between constructs and visible nonverbal behavior (e.g., Hall et al. 2005). Obviously, the contribution to the development of scientific knowledge is not the same for each paper.

To understand the contribution of a paper to a research field, an important metric is the number of times it is cited by other researchers. Bibliographic electronic databases such as Web of Science, APA PsycNET, Scopus, and even Google Scholar, systematically record the citation index, which allows researchers to identify the most cited publications and thereby the publications that theoretically contributed the most to their research field. The availability of those large bibliographic electronic databases as well as their computer algorithms covering a massive number of documents has given a great impetus to bibliometrics, that is "the application of mathematics and statistical methods to books and other media of communication" (Pritchar 1969, p. 349). Bibliometrics is notably used to provide quantitative analysis of scientific literature (Guilera et al. 2013) and to make research funding decisions (Lauer et al. 2015), but is also a research field in itself. Bibliometric analysis has documented the evolution over the years of peer reviewed papers in several research fields (e.g., Hoppen and Vanz 2016; Ivanovic et al. 2015; Pan et al. 2013).

In this article, we use one of the key bibliometric methods, the index of citations, and a comprehensive multidisciplinary bibliographic electronic database, Web of Science, to provide a circumscribed descriptive analysis of 1000 most cited papers in the research field of visible nonverbal behavior. We use these methods to outline the most influential topics and research programs, and to sketch the development of relevant features over the years. We chose Web of Science because it covers a wider range of fields than specialized databases (e.g., PubMed, PsycNet), it provides a higher capability for citation analysis across

the years than Scopus, and it is more frequently updated with citation information than Google Scholar (Falagas et al. 2008). Moreover, we compare the 1000 most cited papers with two corpora, 500 papers randomly selected (i.e., random sample control group) and the 500 most recent papers on visible nonverbal behavior (i.e., current papers group), to provide a more thorough understanding of the current state and possible future directions in visible nonverbal behavior. While they differ from those that emerge from other citation indexes, results are intended to give a flavor of key peer reviewed papers contributing to the development of scientific knowledge on visible nonverbal behavior.

Material and Method

Identification of Papers

Web of Science (WoS), formerly known as Web of Knowledge, is a multidisciplinary bibliographic electronic database providing the overall citation counts from peer reviewed papers since 1945. With 1.3 billion cited references directing to more than 200 million items from 18,000 journals of different disciplines (e.g., agriculture, architecture, anthropology, biology, dance, engineering, language, law, music, film, medicine, physics, psychology, and theater) (Clarivate Analytics 2017; King 2017), WoS is "an indispensable citation database" (Meho and Yang 2007, p. 2123). The identification of the 1000 most cited papers in the research field of visible nonverbal behavior was carried out in a three-step process: (1) An extensive search was done with an idiosyncratic list of keywords related to the research field of visible nonverbal behavior and only papers that contained one of them in their title were retrieved; (2) The results of the extensive search were limited to a definite set of topics and only papers that contained one of them in their title, abstract, author keywords or keywords plus were kept; (3) The search was refined by document types and research areas (Table 1).

The first list included 151,030 papers and, after applying the topics, document types and research areas filters, 30,492 papers were retained to form the initial database. Papers were ranked in descending order based on their number of citations and the first 1000 most cited papers were reviewed by the corresponding author to determine if they were dealing with visible human nonverbal behavior. The corresponding author has been trained in behavioral biology (ethology) and published several papers dealing with behavioral observations (e.g., Plusquellec and Bouissou 2001; Plusquellec et al. 2007, 2010, 2011; Verner et al. 2015). Papers excluded mainly addressed animal issues or presented studies not clearly dealing with visible human nonverbal behavior. For example, papers related to nonverbal intelligence tests, such as the Raven test, or cybernetics were excluded.

The list of the 1000 most cited papers on visible nonverbal behavior covers a wide range of topics. For example, methodological studies evaluate the validity of tools to assess nonverbal behavior (e.g., Hall 1963; Tottenham et al. 2009). Descriptive studies assess the frequency or duration of nonverbal behavior in various situations (e.g., Bentivoglio et al. 1997) or personal conditions (e.g., Yirmiya et al. 1989). Correlational studies deal with associations between the perception and the production of nonverbal behavior and biological or psychological outcomes (e.g., Schneider et al. 1994; Whalen et al. 2001). Predictive studies focus on the variation of nonverbal behavior across human development (e.g., Waite et al. 2005). Finally, intervention studies are concerned with the manipulation of nonverbal behavior abilities and their effect on

Table 1 Information used to identify the 1000 most cited papers in the research field of visible nonverbal behavior

Step 1: An extensive search was made with an idiosyncratic list of keywords related to the research field of visible nonverbal behavior and only papers that contained one of them in their title were retrieved
Keywords: "nonverbal communication" OR "non verbal communication" OR "non verbal behavio*" OR "nonverbal behavio*" OR "nonverbal technique*" OR "nonverbal" OR "body language" OR "Facial action coding system" OR "Facial expression*" OR mimic* OR "interpersonal sensitivity" OR "empathic accuracy" OR "motor empathy" OR "micro*expression" OR "visual display*" OR "body movement*" OR "body expression*" OR "emotion recognition" OR "arm-crossing" OR "eye-contact" OR "motor empathy" OR "emotional feedback" OR gait OR clothing OR "body posture" OR posture OR "hand* movement*" OR "interindividual distance" OR "personal space" OR "personal distance" OR proxemic* OR kinesic* OR "ethological observation*" OR etholog* OR touch* OR haptic OR blink OR self-touch* OR gesture OR "head position" OR immediacy OR emblem* OR "behavio* cue" OR "behavio* indicator" OR handshak* OR "thin*slice judgment*" OR "thin*slice perception" OR "thin slice* of" OR "zero acquaintance" OR ((illustrator OR adaptor OR self-adaptor OR object-adaptor OR regulator) AND hand*)
Step 2: The results of the extensive search were limited to a definite set of topics and only papers that contained one of them in their title, abstract, author keywords or keywords plus were kept.
Topics: "nonverbal communication" OR "non verbal communication" OR "non verbal behavio?r*" OR "nonverbal behavio?r*" OR behavio* OR "body language" OR "nonverbal" OR "behavio* cue" OR emotion*
Step 3: The search was refined by document types and research areas
Document types: article OR clinical trial OR correction OR retraction OR review[1]
Research areas: psychology OR behavioral sciences OR neurosciences neurology OR psychiatry OR cultural studies OR pediatrics OR computer science OR science technologies other topics OR evolutionary biology OR anthropology OR life sciences biomedicine other topics OR business economics OR communication OR geriatrics gerontology OR social issue OR rehabilitation OR social sciences other topics OR education educational research OR ethnic studies OR family studies OR sport sciences OR research experimental medicine OR criminology penology OR robotics

[1]Conference proceedings, meeting reports, books and editorials were excluded from the search

various outcomes (e.g., Holt-Lunstad et al. 2008). The 1000 most cited papers on visible nonverbal behavior therefore include visible human nonverbal behavior as the main dependent or independent variable, and are about the nature, the development, the cause or the function of visible nonverbal behavior (see supplementary materials for the list of the 1000 most cited papers on visible nonverbal behavior).

In order to provide a more thorough understanding of the current state and possible future directions in visible nonverbal behavior, two other corpora of papers were created from the initial database of 30,492 papers. First, the 30,492 papers were ranked in descending order according to their publication year and one every 60 papers dealing with visible human nonverbal behavior was selected without considering the number of citations. These 500 randomly selected papers may be regarded as a representative sample of the papers dealing with visible human nonverbal behavior across the years and will serve as the random sample control group. Subsequently, the 500 most recent papers dealing with visible human nonverbal behavior were extracted from the initial database of 30,492 papers to serve as the current papers group to gain insight on contemporary focuses in the research field of visible nonverbal behavior in comparison to the 1000 most cited papers. The full databases with bibliometric information are available upon request to the corresponding author.

Analysis of Papers

The 1000 most cited papers consist of 12 reviews, 9 meta-analysis, 3 meta-analytic reviews, and 976 original research articles (hereinafter referred to as "articles"). The random sample control group includes 7 reviews, 1 meta-analysis, 1 meta-analytic review, and 491 articles. The current papers group includes 9 reviews, 2 meta-analysis, 1 meta-analytic review, and 488 articles. For each of the 1000 most cited papers, the following information was extracted and analyzed: (1) year of publication; (2) list of authors; (3) title; (4) publication name; (5) number of pages; (6) abstract; (7) number of times cited; (8) recency count (i.e., the number of times the paper was cited within 180 days of the identification of the 1000 most cited papers); (9) keywords. In order to get the authors' affiliation information at the time their paper was published, the list of the 1000 most cited papers was imported in EndNote X7 and the affiliations were obtained using the function *find reference updates*. For the purpose of this article, the department, institution, and country of origin of a paper were taken from the affiliation provided by the first author. If the first author had multiple affiliations, the author's affiliation for correspondence was used for the origin of the paper.

Results

Most Cited Papers

A descriptive analysis of the 1000 most cited papers on visible nonverbal behavior shows that the number of citations for each paper ranges from 39 to 1341 (mean ± SD 119.5 ± 1 27.1; median 80) and five papers were cited more than 1000 times. The most cited paper (Whalen et al. 2001) presents a fMRI study showing the activation of the amygdala in response to pictures of fearful faces. The second most cited paper (Morris et al. 1996) was cited 1242 times and proved from positron emission tomography that the amygdala is engaged in processing the emotional salience of faces, specifically fearful facial expressions. Adolphs et al. (1994), for their part, wrote the third most cited paper, cited 1211 times, where it was highlighted that patients with amygdala lesions have very specific emotion recognition impairments when looking at faces. An older paper, Meltzoff and Moore (1977), the fourth most cited paper, cited 1120 times, demonstrated that infants as young as 12 days of age could imitate facial and hand gestures, a breakthrough discovery considering that in the 1970s, it was believed that infants started imitating gestures between 8 and 12 months of age. Finally, the fifth most cited paper (Breiter et al. 1996) was cited 1052 times and addressed the role of the amygdala in the rapid treatment of emotionally valenced faces using fMRI.

Furthermore, out of the 1000 most cited papers, 14 were cited between 500 and 1000 times. They deal either with neurological mechanisms in the perception of facial expressions (Adolphs 2002; Blair et al. 1999; Morris et al. 1998; Phillips et al. 1997) or with the facial expressions' association with emotions (Ekman 1993), their dynamic (Pantic and Patras 2006), the unconscious facial reactions they elicit (Dimberg et al. 2000), a set of stimuli for their study (Tottenham et al. 2009), methodological issues in their cultural study (Russell 1993), and the way they can be automatically extracted (Fasel and Luettin 2003). These fourteen papers also include perhaps the first article about nonverbal leakages and cues to deception (Ekman and Friesen 1969), an article on gait changes

in older adults (Maki 1997), one review about gender effects in interpersonal sensitivity (Hall 1978), and one meta-analysis on the consideration of thin-slices of expressive visible nonverbal behavior in various contexts (Ambady and Rosenthal 1992).

In the random sample control group, the mean number of citations of the 500 papers randomly selected is 26.8 (SD = 49.5; median 9.0). Moreover, 79 papers (15.8%) from the random sample control group have not yet been cited and 97 papers (19.4%) were cited more than 39 times and are therefore part of the 1000 most cited papers on visible nonverbal behavior.

Publication Years

The 1000 most cited papers were published starting in 1947 (Labarre 1947) up to 2013 (Chartrand and Lakin 2013; Hess and Fischer 2013; Kleinsmith and Bianchi-Berthouze 2013; Ruiz et al. 2013), with the most productive decades being the 2000–2010 period ($n = 51.2$ per year). In the random sample control group, the 500 papers randomly selected were published from 1957 (Ekman 1957) up to 2017 (Motta-Mena and Scherf 2017) and in the current papers group, the 500 most recent papers were published from August 2016 to July/August 2017 and thus can be regarded as the publication trend of last year.

When considering the random sample control group, research scholars increasingly published papers at the beginning of the new millennium. In other words, 24.4% of the papers of the random sample control group were published during the 2000–2010 period and the 2010-present period is the most productive in terms of publications with 37% of the papers in the random sample control group (Table 2).

As shown in Fig. 1, which illustrates the number of papers published per year for the 1000 most cited papers and the random sample control group, the number of papers cited and published increased year after year. The Pearson correlation between the number of papers cited and the number of papers published per year is highly significant when considering years from 1947 to 2010 ($r_{53} = .85$, $p < .001$), remains significant when considering years from 1947 to 2013 ($r_{56} = .52$, $p < .001$), but is no more significant when considering years from 1947 to 2017 ($r_{60} = .24$, $p = .06$).

Table 2 Distribution of the 1000 most cited papers and number of papers in the random sample control group by publication year

Publication year	Nb of papers from the 1000 most cited papers (%)	Nb of papers from the random sample control group (%)
1940–49	1 (0.1)	0
1950–59	0	1 (0.2)
1960–69	28 (2.8)	10 (2)
1970–79	76 (7.6)	52 (10.4)
1980–89	122 (12.2)	61 (12.2)
1990–1999	201 (20.1)	69 (13.8)
2000–2009	512 (51.2)	122 (24.4)
2010–present	60 (6)	185 (37)

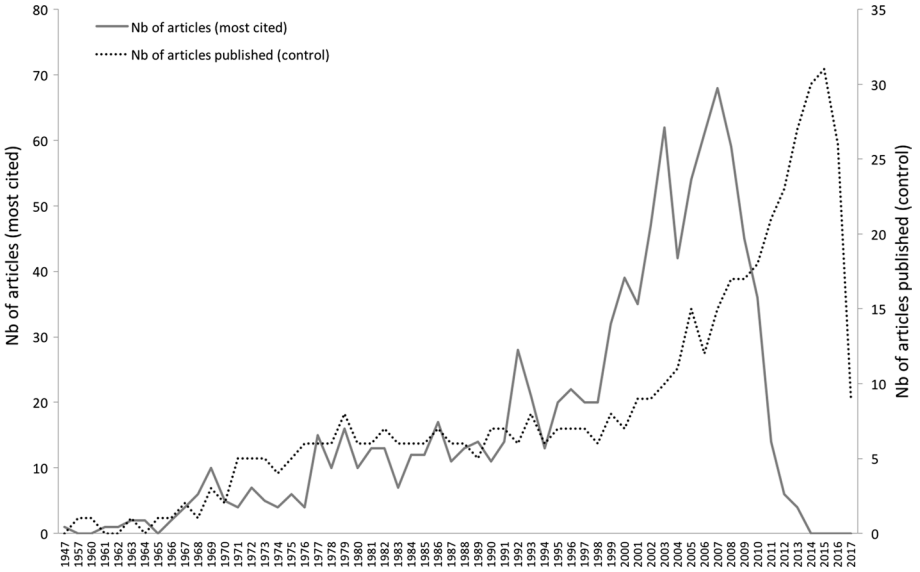

Fig. 1 Distribution of the 1000 most cited papers and number of papers in the random sample control group by publication year from 1947 to 2017

Number of Citations Per Year

To address the impact of the age of a paper on its probability to be cited, we extracted for each of the 1000 most cited papers the number of citations per year since their publication date. Their mean number of citations per year is 8.2 (SD = 8.3) and the mean number of citations per year in the random sample control group is 2.2 (SD = 3.5). With regard to the 1000 most cited papers, the paper with the highest number of citations per year since its publication date (123.7 citations) is Tottenham et al. (2009) where a psychometric evaluation of a set of facial expressions called the *NimStim* was presented. As one could expect, some of the most cited papers are also the papers with the highest number of citations per year since their publication date, that is Whalen et al. (2001) with 74.5 citations, Morris et al. (1996) with 62.1 citations, Adolphs et al. (1994) with 55.0 citations and Breiter et al. (1996) with 52.6 citations. Although not one of the top most cited papers (54th rank), it is worth noting that Guastella et al. (2010), where the effect of intranasal oxytocin on emotion recognition in youth with autism spectrum disorders is addressed, is one of the papers with the highest number of citations per year (52.0 citations).

Recency Counts

In contrast, mean recency counts for the 1000 most cited papers, that is the number of citations within the 180 days of their identification as the 1000 most cited papers (i.e., November 2016), is 4.0 (*SD* = 5.4). The papers with the highest recency counts, which could also be seen as current hotspots in the research field of visible nonverbal behavior, are van Baaren et al. (2004) on the adaptive function of mimicry (112 counts), Carney et al. (2010) on power posing (28 counts), Whalen et al. (2001) on the activation of the amygdala in response to pictures of fearful faces (26 counts), Harms et al. (2010) reviewing facial

emotion recognition in autism spectrum disorders (25 counts), Kleinke (1986) reviewing eye and gaze contact (24 counts), and Chartrand and Lakin (2013) reviewing behavioral mimicry (22 counts). The three other papers that have a recency count higher than 20 deal with facial expressions (Ekman 1993; Pantic and Patras 2006; Sander et al. 2007). It is worth noting that these 9 papers were cited in the last 180 days 10–50 times more than any papers in the research field of visible nonverbal behavior. As a comparison, mean recency counts for the random sample control group is 2.1 (SD = 3.3).

Publication Sources

The 1000 most cited papers come from 297 journals. Further, 33 journals had 7 papers or more, contributing to more than 50% ($n = 515$) of the 1000 most cited papers (Table 3). WoS classifies journals in 225 disciplinary categories (Leydesdorff et al. 2013), differentiating psychology from social psychology, for example. Among the 33 journals with 7 papers or more, 12 are classified in neuroscience (36.4%), 7 in psychology (21.2%), 5 in developmental psychology (15.2%), 4 in experimental psychology, 4 in psychiatry, and 4 in behavioral sciences (12.1%). While journals in neuroscience, psychology and psychiatry prevail in the research field of visible nonverbal behavior, other disciplinary categories typically associated with nonverbal communication such as communication (3.0%), computer sciences (3.0%) and biology (3.0%) are respectively at the 33rd rank, 40th rank, and 46th rank of the 1000 most cited papers.

Surprisingly, the 33 journals with 7 papers or more contained only 20% ($n = 100$) of the papers from the random sample control group (Table 3). In fact, the 500 papers randomly selected come from 323 journals which suggests that a larger number of journals welcome papers on the research field of visible nonverbal behavior. While some journals appear to be cited as much as the estimated number of papers on visible nonverbal behavior they published (e.g., Journal of Nonverbal Behavior, Child Development, Human Communication Research), other journals appear to have more impact (e.g., Journal of Personality and Social Psychology, Neuropsychologia, Emotion).

It is worth noting that the first 251 papers from the random sample control group (50%) were published in 76 journals, including some journals found in the 33 journals with 7 papers or more (e.g., Journal of Nonverbal Behavior, Child Development) but also other journals such as Psychological Reports ($n = 10$; 2%), Plos One ($n = 7$; 1.4%), Frontiers in Psychology ($n = 5$; 1%), Social Behavior and Personality ($n = 5$; 1%), Communication Education ($n = 4$, 0.8%), Infant Behavior and Development ($n = 4$; 0.8%), Pain ($n = 4$; 0.8%), Perception ($n = 4$; 0.8%), Personality and Individual Differences ($n = 4$; 0.8%), and Personality and Social Psychology Bulletin ($n = 4$; 0.8%). Among these 76 journals, 9 are classified in neuroscience (11.8%), 7 in psychology (9.2%), 6 in developmental psychology (7.9%), 11 in social psychology (14.5%), 6 in experimental psychology (7.9%), 11 in psychiatry (14.5%), and 5 in behavioral sciences (6.6%). In addition to these categories, 5 journals are classified in communication (6.6%), 5 in computer sciences (6.6%), and 12 in multidisciplinary psychology and sciences (15.8%).

Moreover, the 33 journals with 7 papers or more that contributed to more than 50% of the 1000 most cited papers includes only 13.6% ($n = 68$) of the papers from the current papers group. In fact, only 13 journals appear in both groups, that is Psychiatry Research, Journal of Nonverbal Behavior, Emotion, Neuropsychologia, Neuroscience and Biobehavioral Reviews, Biological Psychology, International Journal of Psychophysiology, Journal of Autism and Developmental Disorders, Cognition and Emotion, Motivation and

Table 3 Top 50 journals in which the 1000 most cited visible nonverbal behavior papers were published and number of papers from the random sample control group and the current papers group in each of these journals

Rank	Journal	Nb of papers from the 1000 most cited papers (%)	Impact Factor (means from 2010 to 2015)*	Nb of papers from the random sample control group (%)	Nb of papers from the current papers group (%)	Web-of-Science disciplinary categories**
1	Journal of Personality and Social Psychology	79 (7.9)	7.44	4 (0.8)	1 (0.2)	Social Psychology
2	Journal of Nonverbal Behavior	38 (3.8)	2.00	14 (2.8)	8 (1.6)	Social Psychology
3	Neuropsychologia	36 (3.6)	3.67	6 (1.2)	6 (1.2)	Behavioral Sciences, Neurosciences
4	Emotion	25 (2.5)	4.40	2 (0.4)	6 (1.2)	Experimental Psychology
5	Child Development	25 (2.5)	5.81	9 (1.8)	0 (0)	Educational Psychology, Developmental Psychology
6	Psychological Science	21 (2.1)	6.29	6 (1.2)	1 (0.2)	Multidisciplinary Psychology
7	Neuroimage	20 (2.0)	6.80	0 (0)	2 (0.4)	Neurosciences, Neuroimaging, Medicine & Medical Imaging, Nuclear Radiology
8	Psychological Bulletin	19 (1.9)	21.97	3 (0.6)	0 (0)	Psychology
9	Developmental Psychology	17 (1.7)	4.29	3 (0.6)	1 (0.2)	Developmental Psychology
10	Biological Psychiatry	14 (1.4)	10.80	3 (0.6)	0 (0)	Neurosciences, Psychiatry
11	Psychiatry Research	14 (1.4)	2.85	4 (0.8)	10 (2.0)	Psychiatry
12	Cognition & Emotion	14 (1.4)	3.15	8 (1.6)	3 (0.6)	Experimental Psychology
13	Cognition	13 (1.3)	4.31	1 (0.2)	1 (0.2)	Experimental Psychology
14	Journal of Autism and Developmental Disorders	13 (1.3)	4.26	3 (0.6)	4 (0.8)	Developmental Psychology
15	Journal of Abnormal Psychology	13 (1.3)	6.29	1 (0.2)	0 (0)	Clinical Psychology, Psychology, Multidisciplinary

Table 3 (continued)

Rank	Journal	Nb of papers from the 1000 most cited papers (%)	Impact Factor (means from 2010 to 2015)*	Nb of papers from the random sample control group (%)	Nb of papers from the current papers group (%)	Web-of-Science disciplinary categories**
16	Proceedings of the National Academy of Sciences of the United States of America	12 (1.2)	10.28	2 (0.4)	0 (0)	Multidisciplinary Science
17	Journal of Child Psychology and Psychiatry	12 (1.2)	7.14	3 (0.6)	0 (0)	Psychology, Psychiatry
18	Psychophysiology	11 (1.1)	3.56	3 (0.6)	2 (0.4)	Neurosciences, Physiology, Psychology
19	Journal of Cognitive Neuroscience	10 (1.0)	4.59	0 (0)	0 (0)	Neurosciences
20	Brain	9 (0.9)	10.54	0 (0)	0 (0)	Neurosciences, Clinical Neurology
21	American Journal of Psychiatry	9 (0.9)	15.30	1 (0.2)	0 (0)	Psychiatry
22	Biological Psychology	9 (0.9)	3.82	2 (0.4)	4 (0.8)	Behavioral Sciences, Psychology
23	Cortex	9 (0.9)	4.75	6 (1.2)	2 (0.4)	Behavioral Sciences, Neurosciences
24	Journal of Neuroscience	8 (0.8)	6.78	1 (0.2)	0 (0)	Neurosciences
25	Neuroreport	8 (0.8)	1.43	1 (0.2)	0 (0)	Neurosciences
26	Journal of Experimental Social Psychology	8 (0.8)	3.11	3 (0.6)	1 (0.2)	Social Psychology
27	Neuroscience and Biobehavioral Reviews	7 (0.7)	10.50	0 (0)	5 (1.0)	Behavioral Sciences, Neurosciences
28	Science	7 (0.7)	34.92	2 (0.4)	0 (0)	Multidisplinary Science

Table 3 (continued)

Rank	Journal	Nb of papers from the 1000 most cited papers (%)	Impact Factor (means from 2010 to 2015)*	Nb of papers from the random sample control group (%)	Nb of papers from the current papers group (%)	Web-of-Science disciplinary categories**
29	Developmental Science	7 (0.7)	4.68	1 (0.2)	2 (0.4)	Developmental Psychology, Experimental Psychology
30	Neuropsychology	7 (0.7)	3.68	0 (0)	2 (0.4)	Neurosciences, Psychology
31	International Journal of Psychophysiology	7 (0.7)	2.82	1 (0.2)	4 (0.8)	Neurosciences, Psychology, Physiology
32	Motivation and Emotion	7 (0.7)	2.36	3 (0.6)	3 (0.6)	Developmental Psychology
33	Human Communication Research	7 (0.7)	3.71	4 (0.8)	0 (0)	Communication
	(…)					
40	Pattern Recognition	5 (0.5)	3.71	1 (0.2)	4 (0.8)	Computer Science, Artificial Intelligence, Engineering, Electrical and Electronics
	(…)					
46	Current Biology	4 (0.4)	9.73	1 (0.2)	0 (0)	Biochemistry and Molecular Biology, Cell Biology
	(…)					
49	IEEE Transactions on Pattern Analysis and Machine Intelligence	4 (0.4)	8.69	0 (0)	1 (0.2)	Computer Science, Artificial Intelligence, Engineering, Electrical and Electronics
50	IEEE Transactions on Systems Man and Cybernetics part B-Cybernetics	4 (0.4)	6.18	1 (0.2)	0 (0)	Automation & Control Systems, Computer Science, Artificial Intelligence, Cybernetics

*Information retrieved from the Journal Citation Report

**For a detailed description of Web of Science disciplinary categories, see https://jcr.incites.thomsonreuters.com/JCRHomePageAction.action?#

Emotion, Cortex, Developmental Psychology, and Developmental Science (Table 3). Surprisingly, although the Journal of Personality and Social Psychology contains the highest number of papers from the 1000 most cited paper, only one paper from the 500 most recent papers was published in this journal. Also, the first 250 papers from the current papers group (50%) were published in 51 journals including Plos One ($n=27$; 5.4%), Frontiers in Psychology ($n=17$; 3.4%), Scientific Reports ($n=12$; 2.4%), Frontiers in Human Neuroscience ($n=11$; 2.2%), Psychiatry Research ($n=10$; 2%), Multimedia Tools and Applications ($n=9$; 1.8%), IEEE Transactions on Affective Computing ($n=8$; 1.6%), and Journal of Nonverbal Behavior ($n=8$; 1.6%). Among these 51 journals, 16 are classified in neuroscience (31.4%), 9 in psychology (17.6%), 5 in developmental psychology (9.1%), 2 in social psychology (3.9%), 7 in experimental psychology (13.7%), 5 in psychiatry (9.8%), and 5 in behavioral sciences (9.8%). In addition to these categories, 7 journals are classified in computer sciences (13.7%), 6 in multidisciplinary psychology and sciences (11.7%), and 1 in communication (2.0%).

Papers' Authors and Country of Origin

With regard to authors, 743 distinct first authors contributed to the 1000 most cited papers. The first authors' affiliation at the time their paper was published was available for 783 of the 1000 most cited papers showing that 3 countries contributed to more than 66.3% of the 1000 most cited papers: USA ($n=346$), UK ($n=116$) and Germany ($n=57$) (Table 5). Universities from California (USA, $n=50$) and London (UK, $n=43$) particularly contributed to the research field of visible nonverbal behavior. Because it is common practice to have as the first author the research scholar who contributed the most to the work, including the writing of the manuscript, and to have as the last author the senior author (e.g., the director of the lab), the number of papers as first or last authors was used to identify researchers who contributed the most to the 1000 most cited papers on visible nonverbal behavior. Paul Ekman has the highest number of papers (17) as first or last author, followed by Albert Mehrabian (16), and James A. Russell (15) (Table 4).

With regard to the random sample control group, the number of papers from the USA, UK, and Germany account for 52.3% of the 500 randomly selected papers (Table 5). Other countries such as Japan, France, Finland, China, Spain, South Korea, Turkey, Taiwan, Iran, and Czech Republic account for 19.5%. In the current papers group, the USA, the UK, and Germany again contributed to 41.6% of the papers published from August 2016 to July/August 2017. Interestingly, Germany, Italy, Australia, Belgium, Switzerland, Israel, Spain, China, Brazil, Ireland, Poland, and Portugal appear to have contributed more in the last year than previously (1.6–5 times more papers in the current papers group than in the random sample control group), and they account together for 39,9% of the papers in the current papers group. China takes the 4th rank in the number of papers published last year, while it held the 18th rank in the number of citations. Research scholars from the USA appear to have published fewer papers last year than usual.

Content of Papers

Using a list of keywords (Table 6), a rudimentary analysis of the content of the 1000 most cited papers was performed by counting the number of papers where each keyword or set of keywords is present either in the title or in the abstract (an abstract is available in 742 of the 1000 most cited papers). According to channels keywords, the analysis showed that

Table 4 Top 30 authors who contributed to the 1000 most cited papers on visible nonverbal behavior

Author	Nb of articles as		Total	Current position	Faculty/Lab website
	First author	Last author			
Ekman, Paul	10	7	17	Professor Emeritus in psychology at UCSF (USA)	http://www.paulekman.com
Mehrabian, Albert	9	7	16	Professor Emeritus in psychology at UCLA (USA)	https://www.psych.ucla.edu/faculty/page/mehrab
Russell, James A.	7	8	15	Professor in psychology at Boston College (USA)	https://www.bc.edu/bc-web/schools/mcas/departments/psychology/people/faculty-directory/james-russell.html
Phillips, Mary L.	5	9	14	Professor in psychiatry at University of Pittsburgh (USA)	http://phillips.pitt.edu
de Gelder, Beatrice	3	10	13	Professor in cognitive neuroscience at Maastricht University (The Netherlands)	http://www.beatricedegelder.com
Buck, Ross	7	5	12	Professor in communication and psychology at University of Connecticut (USA)	http://comm.uconn.edu/faculty/buck/
Hess, Ursula	7	5	12	Professor in psychology at Humboldt University of Berlin (GE)	http://www.ursulakhess.com
Adolphs, Ralph	6	5	11	Professor in psychology and neuroscience at Caltech (USA)	https://www.bbe.caltech.edu/content/ralph-adolphs
Ambady, Nalini	6	5	11	Professor in psychology at Stanford University (died in 2013) (USA)	http://ambadylab.stanford.edu/ambady.html
Hall, Judith A.	7	4	11	University Distinguished Professor in psychology at Northeastern University (USA)	http://www.northeastern.edu/cos/faculty/judith-hall/
Burgoon, Judee K.	7	2	9	Professor in communication, family studies and human development at the University of Arizona (USA)	https://mis.eller.arizona.edu/people/judee-burgoon
Nelson, Charles A.	4	5	9	Professor in pediatrics at Harvard University (USA)	http://www.hms.harvard.edu/dms/neuroscience/fac/nelson.php
Kleck, Robert	2	7	9	Professor Emeritus in psychology and brain science at Dartmouth college (USA)	https://kleck.socialpsychology.org
Calder, Andrew J.	7	1	8	Professor in neuroscience at Cambridge University (died in 2013) (UK)	https://www.theguardian.com/science/2013/nov/21/andy-calder-obituary
Dimberg, Ulf	5	3	8	Professor in psychology at Uppsala University (Sweden)	http://www.psyk.uu.se/research/researchers/
Friedman, Howard S.	6	2	8	Distinguished Professor of psychology at the University of California (USA)	http://www.psychology.ucr.edu/faculty/friedman/

Table 4 (continued)

Author	Nb of articles as		Total	Current position	Faculty/Lab website
	First author	Last author			
Goldin-Meadow, Susan	3	5	8	Distinguished Service Professor of psychology at the University of Chicago (USA)	https://goldin-meadow-lab.uchicago.edu
Matsumoto, David	4	3	7	Professor in psychology at San Francisco State University (USA)	http://www.davidmatsumoto.com
Vrij, Aldert	6	1	7	Professor in psychology at University of Portsmouth (UK)	http://www.port.ac.uk/department-of-psychology/staff/professor-aldert-vrij.html
Rosenthal, Robert	1	6	7	DWWistinguished Professor in psychology at University of California Riverside (USA)	http://www.psych.ucr.edu/faculty/rosenthal/index.html
Keltner, Dacher	2	5	7	Professor in psychology at University of California Berkeley (USA)	http://psychology.berkeley.edu/people/dacher-keltner
Scherer, Klaus R.	2	5	7	Professor in psychology at University of Geneva (Switzerland)	http://neurocenter.unige.ch/groups/scherer.php
Young, Andrew W.	2	5	7	Professor in psychology at University of York (UK)	https://www.york.ac.uk/psychology/staff/faculty/awy1/#profile
Elfenbein, Hillary A.	6	0	6	Professor in organizational behavior at Washington University (USA)	http://apps.olin.wustl.edu/faculty/elfenbeinh/
Mundy, Peter	5	1	6	Professor in psychiatry and behavioral sciences at University of California Davis	http://www.ucdmc.ucdavis.edu/mindinstitute/ourteam/faculty/mundy.html
Dolan, Raymond J.	1	5	6	Professor in cognition, emotion and psychiatric disorders at University College London (UK)	http://www.fil.ion.ucl.ac.uk/Dolan/
Gur, Ruben C.	1	5	6	Professor in psychology and psychiatry at University of Pennsylvania	http://www.med.upenn.edu/apps/faculty/index.php/g293/p3226
Blair, Robert James R.	2	4	6	Researcher in affective cognitive neuroscience at National Institute of Mental Health (USA)	http://www.nimh.nih.gov/labs-at-nimh/principal-investigators/james-blair.shtml
DePaulo, Bella M.	3	2	5	Project Scientist in psychology at the University of California (USA)	http://belladepaulo.com
Gifford, Robert	3	2	5	Professor in psychology of University of Victoria (CA)	https://www.uvic.ca/socialsciences/psychology/people/faculty-directory/giffordrobert.php

Table 5 Country of origin of the 1000 most cited papers, number of papers from the random sample control group and from the current papers group

Country	Nb of papers from the 1000 most cited papers (%)	Mean nb of citations per paper for the 1000 most cited papers	Nb of papers from the random sample control group (%)	Nb of papers from the current papers group (%)
USA	346 (44.2)	124.61	138 (36.3)	67 (20.7)
UK	116 (14.8)	152.22	40 (10.5)	40 (12.3)
Germany	57 (7.3)	93.12	21 (5.5)	28 (8.6)
Canada	44 (5.6)	88.3	20 (5.3)	16 (4.9)
The Netherlands	36 (4.6)	110.69	18 (4.7)	13 (4.0)
Italy	25 (3.2)	85.36	10 (2.6)	15 (4.6)
Australia	22 (2.8)	108.54	11 (2.9)	15 (4.6)
Japan	19 (2.4)	85.11	19 (5.0)	10 (3.1)
France	17 (2.2)	74.66	13 (3.4)	14 (4.3)
Belgium	16 (2.0)	70.5	3 (0.8)	5 (1.5)
Switzerland	16 (2.0)	99.5	6 (1.6)	11 (3.4)
Sweden	16 (2.0)	148.13	3 (0.8)	4 (1.2)
Israel	10 (1.3)	92.6	3 (0.8)	11 (3.4)
Austria	6 (0.8)	60.5	4 (1.1)	2 (0.6)
Finland	5 (0.6)	89.6	7 (1.8)	7 (2.2)
Spain	5 (0.6)	76	4 (1.1)	8 (2.5)
New Zealand	4 (0.5)	99.75	3 (0.8)	1 (0.3)
China	3 (0.4)	70.67	11 (2.9)	21 (6.5)
Greece	3 (0.4)	67	2 (0.5)	0 (0.0)
Hungary	3 (0.4)	108.33	1 (0.3)	0 (0.0)
Argentina	2 (0.3)	56.5	0 (0.0)	2 (0.6)
Brazil	2 (0.3)	190	1 (0.3)	5 (1.5)
India	2 (0.3)	168	3 (0.8)	2 (0.6)
Croatia	1 (0.1)	57	1 (0.3)	0 (0.0)
Ireland	1 (0.1)	48	0 (0.0)	5 (1.5)
London	1 (0.1)	215	0 (0.0)	0 (0.0)
Norway	1 (0.1)	53	2 (0.5)	2 (0.6)

Table 5 (continued)

Country	Nb of papers from the 1000 most cited papers (%)	Mean nb of citations per paper for the 1000 most cited papers	Nb of papers from the random sample control group (%)	Nb of papers from the current papers group (%)
Poland	1 (0.1)	65	1 (0.3)	3 (0.9)
Russia	1 (0.1)	131	2 (0.5)	0 (0.0)
Singapore	1 (0.1)	169	0 (0.0)	0 (0.0)
South Korea	1 (0.1)	188	6 (1.6)	4 (1.2)
Bangladesh	0 (0.0)	–	1 (0.3)	0 (0.0)
Chile	0 (0.0)	–	0 (0.0)	1 (0.3)
Czech Republic	0 (0.0)	–	3 (0.8)	0 (0.0)
Denmark	0 (0.0)	–	0 (0.0)	1 (0.3)
Estonia	0 (0.0)	–	0 (0.0)	1 (0.3)
Iran	0 (0.0)	–	3 (0.8)	0 (0.0)
Malaysia	0 (0.0)	–	2 (0.5)	0 (0.0)
Mexico	0 (0.0)	–	1 (0.3)	0 (0.0)
Nigeria	0 (0.0)	–	1 (0.3)	0 (0.0)
Portugal	0 (0.0)	–	1 (0.3)	3 (0.9)
Romania	0 (0.0)	–	1 (0.3)	1 (0.3)
Saudi Arabia	0 (0.0)	–	1 (0.3)	0 (0.0)
Serbia	0 (0.0)	–	1 (0.3)	1 (0.3)
Slovakia	0 (0.0)	–	0 (0.0)	1 (0.3)
Slovenia	0 (0.0)	–	2 (0.5)	0 (0.0)
South Africa	0 (0.0)	–	1 (0.3)	0 (0.0)
Taiwan	0 (0.0)	–	3 (0.8)	0 (0.0)
Thailand	0 (0.0)	–	1 (0.3)	0 (0.0)
Turkey	0 (0.0)	–	5 (1.3)	4 (1.2)
Missing	*217*		*120*	*176*

Table 6 Number of papers in which keywords are in the title or in the abstract

	Keywords	The 1000 most cited papers								Random sample control group		Current papers group	
		Nb of articles with keywords in the title per decades (%)						Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)
		1947–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–present						
Channels	Facial expression	3 (10.3)	11 (14.5)	41 (33.6)	100 (49.8)	234 (45.7)	13 (21.7)	402 (40.2)	348 (46.9)	148 (29.6)	138 (38.7)	151 (30.2)	187 (38.2)
	Body movement, body expression, gesture, gait	2 (6.9)	3 (3.9)	16 (13.1)	25 (12.4)	53 (10.4)	6 (10.0)	105 (10.5)	90 (12.1)	36 (7.2)	50 (14.0)	81 (16.2)	93 (19.0)
	Touch, haptic	0 (0.0)	4 (5.2)	1 (0.8)	6 (3.0)	29 (5.7)	6 (10.0)	46 (4.6)	43 (5.8)	29 (5.8)	17 (4.8)	43 (8.6)	51 (10.4)
	Eye contact, blink	0 (0.0)	1 (1.3)	2 (1.6)	2 (1.0)	8 (1.6)	1 (1.7)	45 (4.5)	25 (3.4)	11 (2.2)	8 (2.2)	13 (2.6)	16 (3.3)
	Body posture, posture	2 (6.9)	1 (1.3)	2 (1.6)	4 (2.0)	18 (3.5)	1 (1.7)	28 (2.8)	37 (5.0)	24 (4.8)	23 (6.4)	13 (2.6)	17 (3.5)
	Interindividual distance, personal space, personal distance, proxemics	6 (20.7)	3 (3.9)	2 (1.6)	2 (1.0)	4 (0.8)	0 (0.0)	17 (1.7)	10 (1.3)	14 (2.8)	6 (1.7)	9 (1.8)	13 (2.7)
	Hand movement, self-touch, emblem, handshake, illustrator, adaptor, self-adaptor, object-adaptor, regulator	0 (0.0)	0 (0.0)	2 (1.6)	0 (0.0)	4 (0.8)	0 (0.0)	6 (0.6)	20 (2.7)	3 (0.6)	7 (2.0)	4 (0.8)	11 (2.2)
	Microexpression	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)	3 (0.4)	0 (0.0)	0 (0.0)	1 (0.2)	2 (0.4)
	Clothing	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	1 (0.1)	2 (0.3)	5 (1.0)	3 (0.8)	8 (1.6)	10 (2.0)

Table 6 (continued)

	Keywords	The 1000 most cited papers								Random sample control group		Current papers group	
		Nb of articles with keywords in the title per decades (%)						Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)
		1947–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–present						
Various topics	Emotion recognition	0 (0.0)	1 (1.3)	6 (4.9)	9 (4.5)	83 (16.2)	21 (35.0)	120 (12.0)	106 (14.3)	59 (11.8)	55 (15.4)	94 (18.8)	79 (16.2)
	Children, child	2 (6.9)	9 (11.8)	17 (13.9)	16 (8.0)	32 (6.2)	3 (5.0)	79 (7.9)	75 (10.1)	52 (10.4)	46 (12.9)	45 (9.0)	69 (14.1)
	Psychiatric illness, schizophrenia, depression, anxiety, mental health	0 (0.0)	5 (6.6)	1 (0.8)	9 (4.5)	45 (8.8)	6 (10.0)	77 (7.7)	107 (14.4)	24 (4.8)	40 (11.2)	35 (7.0)	70 (14.3)
	Brain, neuron*, MRI, neural	0 (0.0)	0 (0.0)	1 (0.8)	11 (5.5)	63 (12.3)	2 (3.3)	77 (7.7)	313 (42.2)	16 (3.2)	64 (17.9)	35 (7.0)	103 (21.1)
	Mimic*, imitat*	0 (0.0)	1 (1.3)	4 (3.3)	9 (4.5)	32 (6.2)	3 (5.0)	49 (4.9)	72 (9.7)	19 (3.8)	27 (7.6)	26 (5.2)	51 (10.4)
	Autism, autistic	0 (0.0)	1 (1.3)	8 (6.6)	7 (3.5)	23 (4.5)	7 (11.7)	46 (4.6)	52 (7.0)	14 (2.8)	20 (5.6)	16 (3.2)	24 (4.9)
	Cultur*	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.0)	1 (0.2)	0 (0.0)	25 (2.5)	31 (4.2)	13 (2.6)	16 (4.5)	7 (1.4)	20 (4.1)
	Automatic, computer, artificial intelligence, deep learning, emotional computing, affective computing, robot*	0 (0.0)	0 (0.0)	0 (0.0)	5 (2.5)	16 (3.1)	2 (3.3)	22 (2.2)	88 (11.9)	17 (3.4)	61 (17.1)	18 (3.6)	90 (18.4)
	Interpersonal sensitivity, empathic accuracy	0 (0.0)	1 (1.3)	1 (0.8)	5 (2.5)	10 (2.0)	3 (5.0)	20 (2.0)	16 (2.2)	11 (2.2)	8 (2.2)	8 (1.6)	7 (1.4)
	Nonverbal cues	1 (3.4)	7 (9.2)	3 (2.5)	2 (1.0)	2 (0.4)	0 (0.0)	15 (1.5)	9 (1.2)	9 (1.8)	8 (2.2)	3 (0.6)	7 (1.4)
	Aging, elder	0 (0.0)	0 (0.0)	0 (0.0)	3 (1.5)	6 (1.2)	1 (1.7)	10 (1.0)	102 (13.7)	2 (0.4)	38 (10.6)	7 (1.4)	36 (7.4)

Table 6 (continued)

Keywords	The 1000 most cited papers								Random sample control group		Current papers group	
	Nb of articles with keywords in the title per decades (%)						Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)	Nb of articles with keywords in the title (%)	Nb of articles with keywords in the abstract (%)
	1947–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–present						
Thin-slice judgment, thin-slice perception, thin slice, zero-acquaintance	0 (0.0)	0 (0.0)	0 (0.0)	4 (2.0)	5 (1.0)	0 (0.0)	9 (0.9)	7 (0.9)	0 (0.0)	5 (1.4)	1 (0.2)	2 (0.4)
Deception, deceptive, credibility, trustworthiness	1 (3.4)	0 (0.0)	2 (1.6)	4 (2.0)	2 (0.4)	0 (0.0)	9 (0.9)	18 (2.4)	4 (0.8)	7 (2.0)	1 (0.2)	5 (1.0)
Dominance, hierarchy, social power	0 (0.0)	0 (0.0)	4 (3.3)	0 (0.0)	3 (0.6)	1 (1.7)	8 (0.8)	14 (1.9)	4 (0.8)	6 (1.7)	1 (0.2)	5 (1.0)
Immediacy	0 (0.0)	1 (1.3)	4 (3.3)	1 (0.5)	1 (0.2)	0 (0.0)	7 (0.7)	2 (0.3)	11 (2.2)	13 (3.6)	4 (0.8)	4 (0.8)
Evolution, phylogenet	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (1.2)	0 (0.0)	6 (0.6)	25 (3.4)	1 (0.2)	9 (2.5)	1 (0.2)	13 (2.7)
Physician, clinician	0 (0.0)	0 (0.0)	3 (2.5)	1 (0.5)	1 (0.2)	0 (0.0)	5 (0.5)	8 (1.1)	1 (0.2)	6 (1.7)	2 (0.4)	13 (2.7)
Job interview, negotiation, business	0 (0.0)	1 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.2)	3 (0.6)
Nb of papers where the information is available	29	76	122	201	512	60	1000	742	500	357	500	489

"facial expression" is the most frequent keyword in titles and abstracts (Table 6, respectively, $n=402$ out of 1000 and $n=348$ out of 742), followed by "body movement", "body expression", "gesture" and "gait" ($n=105$ and n = 90), "touch" and "haptic" ($n=46$ and $n=43$), "eye-contact", "blink" ($n=45$ and $n=25$), "posture", "body posture" ($n=28$ and $n=37$) and "interindividual distance", "personal space", "personal distance", and "proxemics" ($n=17$ and $n=10$).

When separating those numbers by decades, apart from the 1947–1969 and 2010- periods, the number of papers dealing with "facial expression" is the highest in each decade, culminating in the 1990–1999 and 2000–2009 periods when the number of papers dealing with facial expression reached respectively 49.8 and 45.7%. However, in the 1947–1969 period, 29 papers published are part of the 1000 most cited papers, and 20.7% of them deal with proxemics, while only 10.3% of them deal with facial expression. According to Table 6, while papers about "body movement", "body expression", "gesture", and "gait" drew more attention starting in the 1980s when the proportion of papers about this channel reached 13.1% and remained constant in the following years, the most cited papers about "touch" and "haptics" started to get published in the 1970s and increased continuously from the 1990s to the 2010s, reaching a peak in the 2000s.

When looking at the random sample control group, the number of papers about "facial expression" dominates once again the research field of nonverbal visible behavior and is present in 29.6% of the title and 38.7% of the abstracts, followed by "body movement", "body expression", "gesture", and "gait" present in 7.2% of the titles and 14% of the abstracts. The current papers group confirms that the "facial expression" channel is still the most studied from August 2016 to July/August 2017 (in 30.2% of the titles and 38.2% of the abstracts) and channels related to body movement and touch are on the rise (respectively in 16.2% of the titles and 19.0% of the abstracts, and in 8.6% of the titles and in 10.4% of the abstracts).

According to various topics keywords (Table 6), "emotion recognition" is the most frequent keyword in titles ($n=120$ and $n=106$), followed by "children" and "child*" ($n=79$), "psychiatric illness", "schizophrenia", "depression", "anxiety", and "mental health" ($n=77$), and "brain", "neuron*", "MRI", and "neural" ($n=77$). In abstracts, the most frequent keyword is "brain", "neuron*", "MRI", and "neural" ($n=313$), followed by "psychiatric illness", "schizophrenia", "depression", "anxiety", and "mental health" ($n=107$), "emotion recognition" ($n=106$), and "aging", and "elder" ($n=102$). When separating those numbers by decades, the most cited papers in the 1970s address topics related to children, mental health and nonverbal cues accounting for 27.3% of the most cited papers of this period. The most cited papers from the 1980s are mainly about children, autism, emotion recognition, imitation, social power, and immediacy topics with 35.3% of the most cited papers. In the 1990s, the most cited papers deal, for the most part, with children, neuronal correlates, mental health, emotion recognition, imitation and autism topics with 30.5% of the most cited papers. In the 2000s, emotion recognition, neuronal correlates, mental health, children, imitation, autism and computer are the topics primarily addressed with 57.3% of the most cited papers. Finally, the most cited papers from 2010 to this day are mainly about emotion recognition, autism, mental health, empathic accuracy, children, imitation, neuronal correlates, and computer topics with 78,3% of the most cited papers from this period.

When compared with the random sample control group and the current papers group (Table 6), it is worth noting that emotion recognition topics appear not to be overrepresented in the 1000 most cited papers since they are present in 11.8% of the title of papers in the random sample control group. However, there is a large increase of their frequency of

appearance in the title of papers in the current papers group (18.8%). On the opposite, topics related to mental health and neural correlates appear to be overrepresented in the 1000 most cited papers since they are present respectively in 4.8 and 3.2% of the title of papers in the random sample control group. However, the frequency of those two topics increases in the titles of papers in the current papers group (7 and 7%).

Finally, Wordle.net, a free online tool to generate "word clouds" with greater prominence for words that appear more frequently in a source text, was used to visually highlight the most prevailing words used in the titles of the 1000 most cited papers, that is "facial", "expression", "recognition" and "emotion" (Fig. 2).

Discussion

Bibliometrics analysis started in the 1960s (Donohue 1972; Saracevic and Perk 1973) and are used in various research fields, notably in environmental health (Hu et al. 2010) and neuroimaging (Kim et al. 2016). To our knowledge, it is the first time that this type of analysis is performed in the research field of visible nonverbal behavior. Our descriptive bibliometric analysis shows that the 1000 most cited papers on visible nonverbal behavior emerged in the 1960s, and peaked in 2008. More than 50% of the 1000 most cited papers were published after 2000. While they highlight the development of scientific knowledge about nonverbal communication for more than 50 years, our results also indicate a renewed interest for the research field of visible nonverbal behavior, probably because of the modernization of observational methods, such as video recordings and computing advances.

A strength of our descriptive bibliometric analysis is the compilation of the exhaustive list of the 1000 most cited papers about visible nonverbal behavior across a wide variety of disciplines including the medical, social, and biological sciences. Although 33 journals contributed to more than 50% of the 1000 most cited papers, and pertained mainly to neuroscience, psychology, psychiatry, and behavioral sciences, it is worth noting the huge number of distinct journals from various disciplines such as computer science, artificial intelligence, engineering, electrical and electronics (e.g., *Pattern Recognition,* Fasel

Fig. 2 "Word cloud" generated from words used in the titles of the 1000 most cited papers on visible nonverbal behavior

and Luettin 2003; *IEEE Transactions on Systems, Man and Cybernetics,* Pantic and Patras 2006), anthropology (e.g., *Yearbook of Physical Anthropology*, Schmidt and Cohn 2001), ethology (e.g., *Ethology and Sociobiology*, Moore 1985), robotics (e.g., *Robotics and Autonomous Systems*, Arkin 2003), medicine (e.g., *Journal of General Internal Medicine*, Griffith et al. 2003), and communication (e.g., *Journal of Communication,* Nguyen et al. 1975). Such a wide variety of disciplines shows how visible nonverbal behavior is a highly multi- and interdisciplinary research field and how scientific knowledge about nonverbal communication goes far beyond social psychology.

For example, 4 out of the 5 most cited papers dealt with the amygdala, therefore demonstrating that one leading discipline in the research field of visible nonverbal behavior is neuroscience. The 5th most cited paper dealt with imitations in infants (Meltzoff and Moore 1977) and show how a simple but rigorous protocol of observation can change the way research scholars see child development. As previously described, the 14 papers cited between 500 and 1000 times are also quite representative of the research field of visible nonverbal behavior since they address issues related to facial expressions, neuroscience and, to a lesser extent, empathic accuracy, gait, and deception.

Another strength of our bibliometric analysis is the creation of two other corpora, the 500 papers randomly selected (i.e., random sample control group) and the 500 most recent papers (i.e., current papers group) on visible nonverbal behavior. In comparison with the 1000 most cited papers, both groups allowed a more thorough understanding of the current state and possible future directions in visible nonverbal behavior.

For example, up until 2013, the number of papers published per year from the 1000 most cited papers are significantly correlated with the number of papers published per year from the random sample control group, which indicates that the research field of visible nonverbal behavior appears to continuously produce high impact papers. Moreover, this finding suggests that even if observation, a central research tool of this research field, is subject to several constraints from a methodological point of view, researchers produced decades ago high-quality studies that are still cited today. In addition, after 2013, the discrepancy between the number of papers published per year from the random sample control group and from the 1000 most cited papers reveals that a paper needs several years to enter the group of the 1000 most cited papers in this research field. Indeed, only 6% ($n = 60$) of the 1000 most cited papers were published starting in 2010 and none were published after 2013. To this day, whatever the level of novelty of a paper, 4 years does not appear to be enough to reach a minimum of 39 citations, but this delay could be reduced with an increase of the number of research scholars in the research field of visible nonverbal behavior and papers published.

In terms of sources, the research field of visible nonverbal behavior appears to be mainly centered around journals dealing with neuroscience, developmental/experimental psychology, psychiatry, and behavioral sciences. When compared to the random sample control group, papers published in neuroscience, developmental/experimental psychology, psychology, and behavioral science journals appear to have more impact because they are cited approximately 2–3 more times than the number of papers published in those journals. This observation holds particularly true for neuroscience journals, and may come from the huge amount of research in neuroscience done from 1990 to 2000, termed the "decade of the brain" (Goldstein 1994). On the other hand, some categories had, up to now, surprisingly less impact, notably communication and computer sciences.

Furthermore, in the current papers group, the number of papers published in journals where the 1000 most cited papers predominantly appear is not trivial. In addition, the number of papers published in neuroscience, developmental/experimental psychology, and

behavioral science journals also increased last year in comparison to the random sample control group. Papers in the research field of visible nonverbal behavior published in computer science journals also increased last year while journals addressing social psychology issues appear to be neglected during the same period. In addition, only 14.6% of papers from the current papers group are found in the journals containing 50% of the 1000 most cited papers. This discrepancy may indicate a change of direction in the research field of visible nonverbal behavior, specifically toward more publications in multidisciplinary (e.g., *Plos One*, see Oh et al. 2016) and computer science journals (*IEEE Transactions on Affective Computing*, see Xu et al. 2017).

According to our results, when considering the recency counts for the 1000 most cited papers, mimicry appears to be the main current hotspot with highest recency counts (112 counts) for van Baaren et al. (2004). In this paper, the authors show that mimicry increases prosocial behavior, not only toward the mimicker but also more broadly toward people not concerned by the mimicry situation. The review from Chartrand and Lakin (2013), which has also a high recency count (22 counts), emphasizes the main current hotspot for mimicry. However, this topic does not emerge in the current papers group, thus highlighting the fact that current hotspots do not necessarily emerge from the 500 most recent papers on visible nonverbal behavior.

Our descriptive bibliometric analysis also showed that the USA dominates with 346 of the 1000 most cited papers, which is not surprising considering that the USA accounts for a large part of the worldwide scientific literature in all disciplines taken together (321 846 in 2014 compared to 87 948 in the United Kingdoms, 91 631 in Germany, UNESCO 2015, p. 777). For example, in the medical field which represents almost one third of all scientific publications (UNESCO 2015, p. 780), the strong influence of the USA is well known. In fact, a majority of the publications in the medical field come from this country (e.g., 70% of the 100 most cited anesthetic articles, Baltussen and Kindler 2004; p. 68% in obstetrics and gynecology, Brandt et al. 2010; p. 78% in general surgery, Paladugu et al. 2002; p. 57% in radiology, Yoon et al. 2013). Thus, compared to the medical field, the USA seems to have a lower influence in the research field of visible nonverbal behavior (34.7%), probably because researchers from the UK, as well as from Germany, highly contributed to the 1000 most cited papers. Moreover, the USA, the UK and Germany appear to lead this research field since 66.3% of the 1000 most cited papers and 52.3% of the 500 randomly selected papers are from those three countries.

Also, when looking at the current papers group, one cannot help but notice that fewer papers from the USA were published last year. In contrast, papers from China have become more present, for example, with research from Southwest University (Ding et al. 2016; Li et al. 2016; Ma et al. 2017) or the Chinese Academy of Science (Li et al. 2016; Liu et al. 2016; Zhang et al. 2016; Zhao et al. 2017). In the last year, papers from Israel also emerged from the Bar-Ilan University (Fridenson-Hayo et al. 2016; Jospe et al. 2017) and the University of Haifa (Goldstein et al. 2016, 2017; Peled-Avron et al. 2016). One can hardly explain the reasons underlying a lower participation of the USA in the research field of visible nonverbal behavior, but the emergence of new players alone certainly cannot explain it.

Also, the rudimentary analysis of the content of the 1000 most cited papers offers valuable information on how specific channels and various topics in the research field of visible nonverbal behavior were developed over the years. For example, a high number of the 1000 most cited papers about specific channels were published starting in the 1990s and valuable knowledge was therefore produced from this moment to this day. Also, it is worth noting that early knowledge about visible nonverbal behavior dealt mainly with "facial expression" as well as "interindividual distance", "personal

space", "personal distance", and "proxemics", and knowledge about proxemics developed decades ago is of much more value than knowledge created more recently since the proportion of papers about proxemics in the 1000 most cited papers dropped starting in the 1970s. The most cited papers in the 1990–1999 and 2000–2009 periods, on the other hand, address facial expression topics with 49.8% of the most cited papers in the 1990–1999 period and 45.7% in the 2000–2009 period. While the exact reason explaining this popularity has yet to be determined, one cannot help but think that this success might be related to the popularity of facial expressions as a means to communicate emotion and the widespread use of the *Facial Action Coding System* as a tool to objectively document them (Ekman 2003). Moreover, topics related to facial expressions are studied in a variety of disciplines, notably neuroscience (e.g., Whalen et al. 2001) and mental health (e.g., Turetsky et al. 2007), thus widening the audience and increasing the chance to be cited by other research scholars. However, the proportion of papers on "facial expression" among the 1000 most cited papers dropped since 2010, and other topics gained higher level of interest.

For example, the number of papers on topics related to "touch" and "haptic" increased in the 2000s and continued to grow in the 2010s, this popularity was also confirmed by an increase in the current papers group. In fact, a closer look at recent papers highlights the fact that they address innovative problematics like, for example, the impact of touch in robotics and affective tele-touching (Bianchi et al. 2016; Cabibihan and Chauhan 2017). Papers on "body movement", "body expression", "gesture", and "gait", for their part, are not as popular as papers on "facial expression" (Dael et al. 2012; Huis in't Veld et al. 2014), but the small increase in the number of publications in the last year gives reasons to believe there is a renewed interest, more so considering the publication of methodological papers in relation with captors, video analysis and automatic recognition of patterns (e.g., Enea and Iancu 2016; Gupta et al. 2016; Kurihara et al. 2016; Li et al. 2016; Moschetti et al. 2016).

In addition, the development of various topics in the research field of visible nonverbal behavior over past decades highlights the fact that papers on topics related to emotion recognition, autism, mental health, empathic accuracy, children, imitation, neuronal correlates, and computerized analysis of nonverbal behavior receive growing attention from research scholars who increasingly cite them. In fact, keywords for these topics account for 78.3% of the 1000 most cited papers since 2010. When comparing the 1000 most cited papers to the random sample control group and current papers group, one cannot help but notice that research scholars in the research field of visible nonverbal behavior have become more and more concerned by emotion recognition, mental health, and neuroscience topics, among others, therefore implementing papers published and cited in the previous years regarding topics such as nonverbal behavior perception and expression of people with psychiatric conditions (e.g., Troisi 1999) and the neurobiology of nonverbal behavior (e.g., de Gelder 2006).

Furthermore, the popularity of papers related to computer science and artificial intelligence speak volumes about the emergence of affective computing, a research field which focuses primarily on the automatic detection of emotional facial expressions (e.g., Bartlett et al. 1999, 2014). In fact, some research scholars consider that affective computing is already a game changer in the research field of visible nonverbal behavior (Calvo et al. 2014). However, even if a computer revolution is expected with progress in artificial intelligence, affective computing is not yet a well-established topic in the research field of visible nonverbal behavior, but research scholars in nonverbal communication should not hesitate to take an active role in this expanding and challenging area.

Finally, papers on deception received a low number of citations, an unexpected result considering the media attention this subject received in the past few years. Although Web of Science indexes 79 journals in communication such as the *Journal of Communication* (Impact factor 2.89), *Human Communication Research* (2.4), and *Communication Research* (1.96), as well as 57 journals in criminology, only approximately 1% of the 1000 most cited papers deal with deception (e.g., Burgoon and Buller 1994; DePaulo et al. 1985; Ekman and Friesen 1969; Fiedler and Walka 1993; Hocking and Leathers 1980; Porter and ten Brinke 2008; Sporer and Schwandt 2007; Vrij and Semin 1996; Vrij et al. 2000, 2004, 2016).

Conclusion

While our descriptive bibliometric analysis has helped understanding the current state and possible future directions in visible nonverbal behavior, our results are not without limitations. First, books and chapters were excluded from the 1000 most cited papers and two corpora. However, books and chapters could have provided useful insights in the development of knowledge in the research field of visible nonverbal behavior. For example, books and chapters are publications of choice to open up dialogues between numerous peer reviewed papers and explore ideas that do not easily lend themselves to peer reviewed papers, dialogues and ideas whose contributions to the development of scientific knowledge on visible nonverbal behavior must not be disregarded. Moreover, books and chapters can offer a useful synthesis for researchers who are not familiar with the scientific literature on visible nonverbal behavior, therefore offering highly valuable resources for the development of knowledge in disciplinary categories typically not associated with visible nonverbal behavior.

Second, only English-written papers were selected and this choice likely created a selection bias, probably underestimating, for example, the number of papers from China, Japan, or Russia (respectively 256,834, 73,128, and 29,099 publications all disciplines taken together in 2014, UNESCO 2015, p. 777). Third, although the 500 papers randomly selected (i.e., random sample control group) were selected as randomly as possible, the selection of one for every 60 papers dealing with visible human nonverbal behavior might also be subject to a selection bias. And last, but not least, our descriptive bibliometric analysis was based on a search using an idiosyncratic list of keywords and a single bibliographic electronic database, Web of Science. Some important papers might be missing from this database, and other keywords could have yielded different results. Important papers might also be missing because the first step of the identification process of the 1000 most cited papers was the inclusion of keywords in their title.

However, despite those limitations, our descriptive bibliometric analysis shows that the research field on visible nonverbal behavior extends over several countries, decades and disciplines. It is a research field with solid bases and a long history of research scholars investigating key questions related to social interactions from different perspectives and disciplines other than social psychology and communication typically associated with nonverbal communication. Based on the aforementioned, it seems reasonable to suggest that future research should follow the example of the development of scientific knowledge on facial expressions. In other words, research scholars should focus on developing ways to objectively document each channel using technological and computing advances. Therefore, research scholars in the research field of visible nonverbal behavior should carefully

engage in research about vision analysis, pattern recognition, and artificial intelligence. The research field of visible nonverbal behavior will also likely further address the neurological basis and adaptive functions of all channels, and combinations of channels. In addition, research scholars should also be mindful of the work of Konrad Lorenz, Nikolaas Tinbergen, and Karl Von Frisch who won a Nobel in 1973 for a discipline that is still topical, ethology.

As Tinbergen (2005) wrote in 1963, ethology's study of behaviors aims to answer two questions on four subjects: What are the proximate causes of behaviors (physiological and developmental) and the ultimate causes of behaviors (adaptive value and phylogeny)? Up to now, researchers in the field of visible nonverbal behavior mainly focused on proximate causes, and one could wish for the future that they also look further at what Tinbergen suggested doing (Eibl-Eibesfeldt 1979; Miklosi 1999), even if this requires to get off the beaten track.

Finally, even if the research field of visible nonverbal behavior appears to increasingly address innovative research topics, research scholars should keep in mind that much remains to be learned on the impact of nonverbal communication in multiple high stakes social contexts, for example in courtrooms (Denault 2015), and even if groundbreaking and complex issues are now addressed, research scholars should keep in mind that basic research about nonverbal communication is unknown to several professionals who would otherwise use it as a valuable tool (Denault and Jupe 2017). In other words, given that research is, to a large extent, publicly funded, research scholars should not give a lower priority to less trendy subjects for the benefit of groundbreaking and complex issues unless the knowledge developed in the past is effectively disseminated to those who would benefit most from it. Otherwise, the societal good and relevance of earlier research on nonverbal communication research, as well as future research, could be questioned, nothing to help overturn the general public mistrust of science and stop the so-called experts who promote false beliefs and frivolous notions about nonverbal communication.

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