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Stop touching your face! A systematic review of triggers, characteristics, regulatory functions and neuro-physiology of facial self touch

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ABSTRACT

Spontaneous face touching (sFST) is an ubiquitous behavior that occurs in people of all ages and all sexes, up to 800 times a day. Despite their high frequency, they have rarely been considered as an independent phenomenon. Recently, sFST have sparked scientific interest since they contribute to self-infection with pathogens. This raises questions about trigger mechanisms and functions of sFST and whether they can be prevented. This systematic comprehensive review compiles relevant evidence on these issues. Facial self-touches seem to increase in frequency and duration in socially, emotionally as well as cognitively challenging situations. They have been associated with attention focus, working memory processes and emotion regulating functions as well as the development and maintenance of a sense of self and body. The dominance of face touch over other body parts is discussed in light of the proximity of hand-face cortical representations and the peculiarities of facial innervations. The results show that underlying psychological and neuro-physiological mechanisms of sFST are still poorly understood and that various basic questions remain unanswered.

1. Introduction

1.1. Active and spontaneous facial self-touch

Self-touches are performed manifold every day by every human being. Self-touches (ST) are usually defined as touches of the own body, hands or face and encompass movements such as rubbing, scratching, caressing or holding (Freedman, 1972; Harrigan et al., 1986a). Facial ST (FST) are currently experiencing particular research interest in the context of the Covid-19 pandemic. Touching one's own face can be associated with the transmission of pathogens to the facial mucous membranes by touching the mouth, nose or eyes (Hall and Douglas, 1981; Rusin et al., 2002; Zhao et al., 2012). During 2020, a substantial number of studies was published that addressed the need to reduce face-touching behaviors and examined the impact of physical barriers on FST frequency (Chen et al., 2020; Lucas et al., 2020; Senthilkumaran et al., 2020; Shiraly et al., 2020). Wearing masks was associated with decreased FST frequency, but loose masks that slip off the nose caused increased hand contact with the face (Lucas et al., 2020). Taping the extensor side of the elbow with an adhesive, non-stretch tape – so that attempting to touch oneself in the face was associated with experiencing an uncomfortable sensation – did not result in persistent inhibition of FST behavior (Senthilkumaran et al., 2020). Nevertheless, the consistent call in the aforementioned studies is to stop touching one's own face, given the risk of infection. We propose, that for the investigation and possible prevention of FST at least two types of FST should be differentiated.

One type of FST, which has been called "active" in recent studies, involves planned movements with a distinct purpose. Such a purpose may be to relieve a pain stimulus or itching. Another sort of active FST are gestures that serve communicative functions, like tapping at one's forehead (Harrigan et al., 1991). Likewise, when people brush wisps of hair from their face or pick their nose, the FST follows an obvious goal. Maladaptive touching behaviors such as self-injuring behaviors also represent a purposeful, active FST (Stafford and Cavanna, 2020; Winchel and Stanley, 1991). An increasing number of researchers focus on active FST that are prompted by another person or an external stimulus (Ackerley et al., 2014; Hara et al., 2015; Verrillo et al., 2003). In this context, tools (e.g., brushes) are sometimes used to execute active FST (Tajadura-Jiménez et al., 2013). However, using tools to touch the own face eliminates a distinctive feature of FST: the simultaneous touching of the own skin by the own finger. A multitude of afferent nerve fibers and specialized receptors, subserving proprioceptive (joint, muscle, connective tissue) and cutaneous sensitivity, are activated during the

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execution of FST (for overview of physiological fundamentals of touch see (Abraham and Mathew, 2019; Grunwald, 2008; McGlone and Reilly, 2010).

Another type of FST, which are to be distinguished from active ones, are called "spontaneous" FST (sFST) (DiMercurio et al., 2018; Grunwald et al., 2014; Mueller et al., 2019). The term "spontaneous" means that little or no attention is paid to the initiation and execution of the movements and that the accuracy of remembering this behavior is poor (Ekman and Friesen, 1969a; Hall et al., 2007; Harrigan et al., 1987). Furthermore, there is no obvious motivation underlying sFST and they are not intended to serve communicative or social functions (Butzen et al., 2005; Freedman, 1972; Harrigan et al., 1991; Heaven et al., 2002). The assumption that sFST differ from active FST was supported by the result of a study by Grunwald et al. (2014), who investigated neurophysiological characteristics of sFST. Spontaneous FST that occurred during a working memory task with affective distractors were accompanied by spectral changes indicative of cortical regulatory processes. In contrast, no significant changes were detected before and after active FST when the investigator prompted the participants to touch their faces.

1.2. Objectives

Extrapolations of existing findings reveal that sFST are performed up to 800 times during 16 waking hours/day (Dimond and Harries, 1984; Hatta and Dimond, 1984). Studies on fetuses show that sFST already occur during the prenatal period of humans (Reissland et al., 2014). Moreover, some studies have shown that – in contrast to spontaneous ST (sST) that are directed towards other body parts – sFST occur more frequently (Butzen et al., 2005; Ekman and Friesen, 1972; Harrigan, 1985). To anticipate, detect and suppress this ubiquitous behavior is of vital importance for the containment of infectious diseases. So far, there are no studies examining effective behavioral training to reduce the incidence of sFST and previous attempts to suppress face touching seem to have little success (Heinicke et al., 2020; Lucas et al., 2020; Senthilkumaran et al., 2020). Since sFST are elicited without paying attention to it, it may be difficult to change or suppress this behavior – compared to active FST with a distinct purpose. Decades of ST-research have particularly observed and described the phenomenon of sFST, but central questions still remain unanswered: Why do they occur and how are they elicited? Knowing what triggers sFST could lead to an answer how to reduce this behavior.

We therefore believe that it is crucial to analyze the functional role, trigger mechanisms and psychophysiological mechanisms of sFST. To date, there are no reviews that consolidate the findings of over 50 years of ST research across different research methods and disciplines. Thus, the present review aims to gather relevant research results on sFST and answer the following fundamental questions: In which situations do sFST occur most frequently? (4.1) What are characteristic features of sFST? (4.2) Do attributes of the person influence the occurrence of sFST? (4.3) What are explanatory models for sFST and which functions are attributed to them? (4.4) What are consequences of sFST behavior? (4.5).

2. Methods

2.1. Search strategy

Articles were systematically searched by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The search was performed using the MEDLINE (via PubMed) and PsycInfo (via EBSCO) databases, applying the following search strings: (face OR facial OR head OR self OR body) AND (spontaneous OR spontaneously) AND (touch OR touching OR contact OR grab OR grasp) OR (self-touch OR self-touching). In addition to the databases on medicine and psychology, the Web of Science Core Collection was browsed as a third database, using the key term (self--touch OR self-touching). Search terms were used as words within both abstracts and titles. Searches were limited to studies in peer-reviewed journals. The search encompassed all publication dates since the journal's year of establishment until June 2020. The search was restricted to human samples and English- as well as German-language papers. A few papers were identified manually through the web search engine Google Scholar. Finally, the reference lists of the included papers were examined to identify possible relevant papers.

2.2. Study selection

Inclusion criteria for the current review were (a) investigation of ST of the head/face, (b) ST occurred spontaneously (i.e. not active or upon request), (c) data for the analysis of ST were based on empirical evidence and (d) ST were externally recorded (not via self-report). Two members of the research team independently screened the titles and abstracts of all identified articles to determine if a study met inclusion criteria. Any disputes were resolved by discussion and recurring scrutinizing. Studies for which it was not clearly evident from the abstract whether they fully met the inclusion criteria were reexamined by viewing the full text and evaluated with regard to their eligibility. Of the records that were examined closely, studies that met all inclusion criteria were included in the final review.

2.3. Data extraction

All relevant study and measurement characteristics of the included studies were extracted independently by two members of the research team. Again any controversies were resolved by discussion and recurring scrutinizing. The general study characteristics include year of publication, authors, country, study design, sample characteristics, conditions and main results for sFST (see Table 1). Data of measurement characteristics refer to study setting, length of observation, method of measurement, location of ST, laterality assessment, temporal characteristics and coders (see Table 2).

3. Results

3.1. Study selection

Our initial search yielded a total of 804 original sources. Eight studies were manually identified. After 162 duplicates were removed using the reference management programme Citavi 6 (Swiss Academic Software GmbH), 651 articles remained in the selection process. Two independent raters evaluated each study for inclusion criteria by screening the abstracts. As a result 586 records were determined to not meet inclusion criteria. A full-text review of the remaining 65 articles was conducted. An additional 36 articles were excluded, because the studies did not differentiate ST to the face/head from ST to other areas of the body or the touched body areas were not specified. Other articles did not meet inclusion criteria, because sFST were assessed, but no distinct analysis for facial ST was carried out ($n = 4$). Instead, sFST were pooled together with other forms of ST for further analyses. Another four records were excluded because ST did not occur spontaneously. Finally 21 studies met inclusion criteria and were included in the review (D'Alessio and Zazzetta, 1986; DiMercurio et al., 2018; Dimond and Harries, 1984; Elder et al., 2014; Goldberg and Rosenthal, 1986; Grunwald et al., 2014; Harrigan et al., 1986a,b; Hatta and Dimond, 1984; Johnston et al., 2014; Knöfler and Imhof, 2007; Konishi et al., 1997; Kwok et al., 2015; Moszkowski and Stack, 2007; Mueller et al., 2019; Nicas and Best, 2008; Reissland et al., 2015a,b; Rochat and Hespos, 1997; Zhang et al., 2020). Fig. 1 shows the literature search and the selection process in a flow chart.

Table 1
Overview of general study characteristics.

				Sample Characteristics			Phenomen of Interest	
Year	Study	Country	Design	N	Age (years)	Sex (% male)	Conditions	Main Results for sFST
1984	Dimond & Harries	UK	CT	18	x (students)	50	a) no task b) listening to music c) listening to lecture	Participants showed more left-handed sFST. Duration of left-handed sFST M = 2.29 s; right-handed sFST M = 0.42 s.
			O	6	x (workers)	100	Lunchtime seminar	Most sFST were directed to the chin (57 %).
1984	Hatta & Dimond	UK	CT	36	x (students)	50	a) no task b) listening to music c) listening to lecture	British participants showed more sFST than Japanese participants. Left-hand preference for British people. British people mostly touched their chin (58 %). Japanese people mostly touched their nose (25 %).
1985	Harrigan	USA	O	28 doctors 28 patients	M = 29.5 M = 35.8	71.4 28.5	Medical consultation	Most ST were directed to the head/face/neck area for both doctors (64 %) and patients (55 %).
1986 a	Harrigan et al.	USA	CT	48	M=20.5	52	Scene (ST/control), mode (spontaneous/ posed), role (doctor/ patient), sex (male/ female)	Scenes with sFST were regarded as more demonstrative (outgoing, dominant, expressive, friendly, interested, sociable) than control (no ST) scenes.
1986b	Harrigan et al.	USA	CT	98	M = 19.5	51	Scene (ST/control), mode (spontaneous/ posed), role (doctor/ patient), sex (male/ female)	Scenes with sFST were regarded as more expressive (expressive, dominant, outgoing, interested) and warm than control (no ST) scenes.
1986	D'Alessio & Zazzetta	Italy	O	160	2 years, 8 months to 5 years,10 months	50	Free play	Youngest children showed more ST to the head than older children. Girls showed locational preference for head.
1986	Goldberg & Rosenthal	USA	CT	32 applicants 8 interviewers	x (undergra-duates & graduates)	50	(Sex compostition of dyads); status (applicant/interviewer); formality (high/low)	Participants touched their face more often under informal (M = 0.95 sFST/3 min) than under formal (M = 0.25 sFST/3 min) conditions.
1997	Konishi et al.	Japan	LO	17	29−35 weeks	47	Neonatal care unit	Infants showed more right-handed (M = 1.45 sFST/min) than left-handed (M = 0.91 sFST/min) sFST.
1997	Rochat & Hespos	USA	CT	Group 1: 5 Group 2: 11	Group 1: <18 h Group 2: M = 4.1 weeks	Group 1: 40 Group 2: 45.45	Stimulation (spontaneous self/ external)	Newborns displayed more rooting responses (head turns toward the stimulation with mouth open and tonguing) following external compared to spontaneous self-stimulation. 4-week-old infants demonstrated an opposite pattern.
2007	Knöfler & Imhof	Ger-many	Q	24	24−26	50	Sexual orientation within dyads (heterosexual/ homosexual/ mixed)	Men in concordant dyads showed more sFST than women in concordant dyads. Heterosexual individuals showed more sFST when interacting in mixed dyads as compared to concordant dyads.
2007	Moszkows-ki & Stack	Canada	CT	46 infants	M = 5 months, 13 days	45.4	Interaction (normal/ still-face)	Infants showed more sFST during still-face compared to normal interaction periods.
2008	Nicas & Best	USA	O	10	x (students)	50	Office-type work	M = 15.67 ST to the eyes/ nostrils/ lips per 1 h.
2014	Elder et al.	USA	O	31 clinicians 48 staff	M=40	20	Work at medicine office	M = 9.5 ST to the eyes/ nose/ mouth per 1 h. Clinicians touched their t-zone less than MA/ nursing staff. Participants who stated they frequently avoided touching the t-zone touched it the same rate (M = 9.5/h) as those who reported occasionally or rarely avoiding touching (M = 10/h).
2014	Grunwald et al.	Ger-many	CT	14	M=26.6	40	Negative emotional load (sounds/ sound free phases); working memory load; + reference phase (instructed FST)	Participants showed most sFST during the retention interval. Decrease of spectral theta power before sFST and increase of spectral theta and beta power after sFST. No significant EEG-changes when facial ST were instructed.
2014	Johnston et al.	USA	O	93	x (workers)	56	Laboratory work	Participants showed M = 2.6 sFST per 1 h. Most sFST were directed to the nose. Perceived severity of infection was negatively correlated with frequency of sFST.
2015 a	Reissland et al.	UK	LO	15	24−36 gestational week	46.6	Fetal age; maternal stress (high/ low); sex	Fetuses showed more left-handed sFST under increased perceived maternal stress. Fetuses showed M = 6 sFST per 10 min.
2015 b	Reissland et al.	UK	LO	20	24−36 gestational week	50	Smoking; fetal age; maternal stress and depression	Fetuses showed less sFST with increasing age and more sFST under increased perceived maternal stress. SFST-rate for fetuses of smoking mothers was raised by 69 %

(*continued on next page*)

Table 1 (*continued*)

				Sample Characteristics			Phenomen of Interest	
Year	Study	Country	Design	N	Age (years)	Sex (% male)	Conditions	Main Results for sFST
								compared to nonsmoking mothers. Fetuses showed M = 14.47 ST per 15−20 min.
2015	Kwok et al.	Australia	O	26	x (phase 3 medical students)	x	Listening to university lecture	Students showed M = 24 sFST per 1 h. Duration of sFST was between M = 1 and M = 5 s.
2018	Di Mercurio et al.	USA	LO	4	3 weeks to 9−13 weeks	75	Baseline vs. toys-in-view	Overall, infants showed M = 4.10 sFST per 1 min. Duration of sFST was M = 2.8 s.
2019	Mueller et al.	Germany	CT	60	M=25.7	50	Negative emotional load (sounds/ sound free phases); working memory load	Participants showed most sFST during the retention interval. Most sFST were directed to the middle axis of the face and occurred during sounds. Duration of sFST was M = 1.76 s.
2020	Zhang et al.	China	O	29	21−29 (one participant was 37)	58.6	Student office work	Most of all ST (76.9 %) were directed to the face (M = 36.5 per 1 h) and were contributed by the non-dominant hand. Duration of sFST was M = 145 sec. 42,2% of sFST lasted less than 3 s.

Notes: CT = Controlled trial; O = Observational study; Q = Quasi-experimental design; LO = Longitudinal observational study; x = not reported or specified; sFST = spontaneous facial self-touch; M = Mean; ST = self-touch.

3.2. Study characteristics

The included studies were conducted in the United States (DiMercurio et al., 2018; Elder et al., 2014; Goldberg and Rosenthal, 1986; Harrigan et al., 1986a,b; Harrigan, 1985; Johnston et al., 2014; Nicas and Best, 2008; Rochat and Hespos, 1997), UK (Dimond and Harries, 1984; Hatta and Dimond, 1984; Reissland et al., 2015a,b), Germany (Grunwald et al., 2014; Knöfler and Imhof, 2007; Mueller et al., 2019), Canada (Moszkowski and Stack, 2007), China (Zhang et al., 2020), Australia (Kwok et al., 2015), Japan (Konishi et al., 1997) and Italy (D'Alessio and Zazzetta, 1986) and were published between 1984 and 2020. One article comprises the results of two studies, therefore the extracted data refer to 22 studies (Dimond and Harries, 1984). The chosen study designs were observational studies without any tasks or interventions (D'Alessio and Zazzetta, 1986; Dimond and Harries, 1984; Elder et al., 2014; Harrigan, 1985; Johnston et al., 2014; Kwok et al., 2015; Nicas and Best, 2008; Zhang et al., 2020), controlled trials (Dimond and Harries, 1984; Goldberg and Rosenthal, 1986; Grunwald et al., 2014; Harrigan et al., 1986a,b; Hatta and Dimond, 1984; Moszkowski and Stack, 2007; Mueller et al., 2019; Rochat and Hespos, 1997), controlled trial with a quasi-experimental design (Knöfler and Imhof, 2007) or longitudinal observational studies (DiMercurio et al., 2018; Konishi et al., 1997; Reissland et al., 2015a,b). Sample size of 12 studies was below 30 (DiMercurio et al., 2018; Dimond and Harries, 1984; Grunwald et al., 2014; Knöfler and Imhof, 2007; Konishi et al., 1997; Kwok et al., 2015; Nicas and Best, 2008; Reissland et al., 2015a,b; Rochat and Hespos, 1997; Zhang et al., 2020), in six studies between 30 and 60 (Goldberg and Rosenthal, 1986; Harrigan et al., 1986b; Harrigan, 1985; Hatta and Dimond, 1984; Moszkowski and Stack, 2007; Mueller et al., 2019) and up to 160 in four studies (D'Alessio and Zazzetta, 1986; Elder et al., 2014; Harrigan et al., 1986a; Johnston et al., 2014). In 15 studies participants were adults with mean ages ranging from 19.5–40 years (seven of those studies did not report the exact age of the participants, but referred to students (Dimond and Harries, 1984; Goldberg and Rosenthal, 1986; Hatta and Dimond, 1984; Kwok et al., 2015; Nicas and Best, 2008) or workers (Dimond and Harries, 1984; Johnston et al., 2014), four studies comprised infants (newborns to 5 months (DiMercurio et al., 2018; Konishi et al., 1997; Moszkowski and Stack, 2007; Rochat and Hespos, 1997)), two studies observed fetuses in uterus (24−36 gestational week (Reissland et al., 2015a,b)) and one study comprised toddlers (2–5 years (D'Alessio and Zazzetta, 1986)). The number of female and male participants was equal in nine studies (D'Alessio and Zazzetta, 1986; Dimond and Harries, 1984; Goldberg and Rosenthal, 1986; Harrigan, 1985; Hatta and Dimond, 1984; Knöfler and Imhof, 2007; Mueller et al., 2019; Nicas and Best, 2008; Reissland et al., 2015b), six studies (DiMercurio et al., 2018; Dimond and Harries, 1984; Harrigan et al., 1986a,b; Johnston et al., 2014; Zhang et al., 2020) tested more men (51, 52, 56, 58.6, 75 und 100 % male) and another six studies (Elder et al., 2014; Grunwald et al., 2014; Konishi et al., 1997; Moszkowski and Stack, 2007; Reissland et al., 2015a; Rochat and Hespos, 1997) tested more women (53, 53.4, 54.6, 57.3, 60 und 80 % female). One study did not report any information about gender distribution (Kwok et al., 2015).

4. Results

4.1. In which situations do sFST occur most frequently?

Spontaneous FST often occur when people interact with each other. Four studies investigated sFST during social interaction and indicated that the occurrence of sFST depends on different interpersonal as well as situational factors. Goldberg et al. (1986) examined ST behavior with respect to participants' status (applicant vs. interviewer) and situational formality (employment interview with high formality vs. informal situation where participants were told that there were "technical difficulties" and they should "chat" for a few minutes). The authors found that participants touched their face significantly more often under informal (M = 0.95 sFST/3 min) than under formal (M = 0.25 sFST/3 min) conditions ($F(1,6) = 19.01$, $p < .005$). Elder et al. (2014) observed that nurses (M = 9 sFST/h) and other staff members (M = 16 sFST/h) touched their faces more frequently than physicians and nurse practitioners (M = 5 sFST/h) while performing their usual duties (e.g. front office, medical examination). Harrigan (1985) observed physicians and their patients during medical interviews (M = 11.10 min) about medical problems and psychosocial issues related to that problem. The author found that both physicians and patients performed most self-touches during patients' statements about their illness, feelings and attitudes. In this analysis sFST were pooled together with sST of other body parts. Nonetheless the author stated that the highest incidence of sST occurred on the head/face/neck area for both doctors (64 % of all sST, M = 5.29 sFST) and patients (55 % of all sST, M = 5.75 sFST) across all conditions (question, answer, statement). Another study investigated infant sFST and other sST behavior depending on their mothers availability during a still-face procedure (Moszkowski and Stack, 2007). This procedure consists of two normal face-to-face interaction periods separated by a period where mothers gaze at their infants, while maintaining

Table 2
Overview of measurement characteristics.

Observational Characteristics				Coding Scheme				
							Coders	
Authors (and year)	Setting	Length of observation	Method of measurement	Location of self-touch	Laterality assessed	Temporal characteristics	Trained	Number
Dimond and Harries (1984)	Lab	10 min p.c. / 30 min p.p.	Observation	face	Yes	Duration of touch was assessed	x	x
	Natural work environment	60 min p.p.	Observation	Mouth, chin, nose, cheek, scalp, ear, forehead, eye	No	x	x	x
Hatta and Dimond (1984)	Lab	10 min p.c. / 30 min p.p.	Observation	Mouth, chin, cheek, nose, scalp, forehead, eye	Yes	Duration of touch was assessed	x	1
Harrigan (1985)	Natural work environment	5 to 22 min p.p.	Videotape with audio	Head/face/neck, arm, leg, trunk, clothing	No	During speech or silence; at the beginning, middle or end of an utterance	Yes	2
Harrigan et al. (1986a)	Lab & natural environment	12 s p.c.	Videotape	Face/head	No	SFST shorter than 4 s Included	x	x
Harrigan et al. (1986b)	Lab & natural environment	12 s p.c.	Videotape	Eye, eyebrow, nose, forehead, side of head	No	SFST shorter than 4 s included	x	x
D'Alessio and Zazzetta (1986)	Natural environment	45 min p.p.	Videotape	Head, trunk, feet, legs, arms, hands	No	Duration of touch was assessed but not reported	x	2
Goldberg and Rosenthal (1986)	Lab	3 min p.c. / 6 min p.p.	Videotape	Hair, face, neck, upper torso, lower torso, arm, hand, leg, foot	No	sFST shorter than 5 s included	Yes	2
Konishi et al. (1997)	Neonatal care unit	60 min p.c.	Videotape	Face	Yes	x	x	x
Rochat and Hespos (1997)	Nursery, lab, home	220–380 sec p.c.	Videotape	Face (oral or perioral area)	No	x	x	x
Knöfler and Imhof (2007)	Lab	10 min p.p.	Videotape	Face and other parts of the body	No	x	x	2
Moszkowski and Stack (2007)	Home	2 min p.p.	Videotape	Face/head/shoulder/neck, mouth, hand/arm, trunk, Feet/leg, mother, chair, clothes, no area	No	Motor behavior longer than 1/3 s (1/2 s for static touch)	Yes	2
Nicas and Best (2008)	Lab	180 min p.p.	Videotape	Eyes, lips, nostrils	No	x	x	1
Elder et al. (2014)	Family medicine office	120 min p.p.	Observation	Eyes, mouth, nose	No	x	Yes	3
Grunwald et al. (2014)	Lab	5 min p.c.	Videotape, EEG, EMG	Face	No	x	x	x
Johnston et al. (2014)	Biosafety level-2 laboratories	M = 337 min each laboratory	Observation	Nose, mouth, eye, forehead, cheek, chin; ST of hair, neck and ears were excluded	No	x	x	2
Reissland et al. (2015a)	Radiography department	40 min p.p.	Ultrasound record	Head and face	Yes	x	Yes	2
Reissland et al. (2015b)	Radiography department	60–80 min p.p.	Ultrasound record	Face	No	x	Yes	2
Kwok et al. (2015)	University	240 min p.p.	Videotape	Eyes, nose, mouth, ears, cheeks, chin, forehead, hair	No	Duration of touch was assessed	x	1
DiMercurio et al. (2018)	Lab	5 min p.c.	Videotape	Head (upper & lower + left & right side) and other parts of the body	Yes	sFST longer than 280 ms included	Yes	3
Mueller et al. (2019)	Lab	14 min p.c.	Videotape, EMG, tri-axial acceleration sensors	Face (left/right side and middle axis); ST of hair, head, neck, ears were excluded	Yes	sFST shorter than 10 s included	x	x
Zhang et al. (2020)	Student office	60 h total	videotape	Nose (upper part), nostril, lips, chin, forehead (left & right), eye (left & right), peripheric area of eye (left & right), cheek (left & right), ear (left & right)	Yes	Duration of touch was assessed	Yes	5

Notes: p.c. = per condition; p.p. = per participant; x = not reported or specified; sFST = spontaneous facial self-touch.

an expressionless face and refraining from vocalizing and touching their infants. The sFST frequency of infants quadrupled during the two-minute still-face period compared to the normal interaction periods before and after the still-face period ($F(16,688) = 24.37$, $p < 0.001$).

Spontaneous FST do also occur in absence of social interactions, which was investigated in seven studies. Reissland et al. (2015a,b) examined the effects of perceived maternal stress on fetal ST behavior. The authors noted that maternally reported stress level was positively related to fetal sFST. Additionally, fetuses of smoking mothers showed 69 % more sFST compared to fetuses of nonsmoking mothers (Reissland et al., 2015b). Two studies (Grunwald et al., 2014; Mueller et al., 2019) used an experiment that systematically induced ST: Participants had to

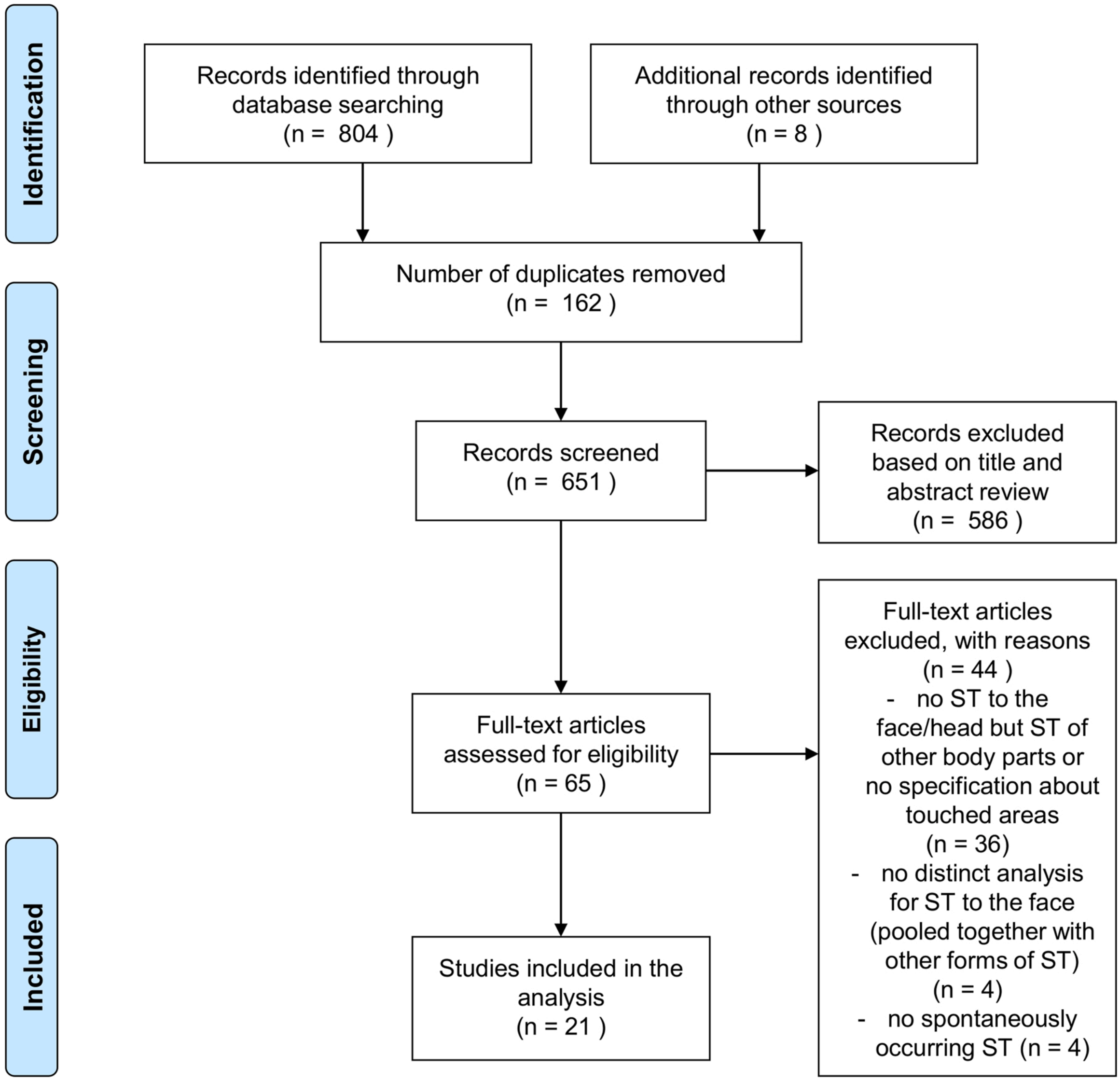

Fig. 1. PRISMA flow chart showing the selection process of literature for the review. ST = self-touch.

perform a delayed memory task of complex haptic stimuli (sunken reliefs). During the retention interval short unpleasant and distracting sounds were presented. In both studies, participants showed significantly more sFST during the retention interval than during haptic exploration and the reproduction period. High-frequency ST behavior was further observed in students working in a graduate student office (M = 36.5 sFST/h (Zhang et al., 2020)) and participants performing office-type work in isolation from other persons (M = 15.67 sFST/h (Nicas and Best, 2008)).

4.2. *What are characteristic features of sFST?*

The following paragraph will outline findings concerning the touched face areas, temporal aspects of sFST and the laterality of hand use. The results are summarized in Fig. 2.

4.2.1. *Touched face area*

Nine studies examined sFST with regard to different face areas, while two studies exclusively captured sFST to the mouth, nose and eyes (T-zone) (Elder et al., 2014; Nicas and Best, 2008). Both studies found that most sFST were directed to the mouth. Elder et al. (2014) observed M = 9.5 sFST/h; the mouth was touched twice as often as the nose or the eyes. Nicas and Best (2008) reported M = 15.7 sFST/h, 50.95 % of that to the mouth. The other studies used further differentiations of facial areas such as the chin, cheeks, forehead and ears (Dimond and Harries, 1984; Hatta and Dimond, 1984; Johnston et al., 2014; Kwok et al., 2015; Zhang et al., 2020) or differentiated the face into left and right sides (DiMercurio et al., 2018; Mueller et al., 2019). Of those studies, two observed the chin to be touched most frequently (57 % and 37.75 % of all sFST) (Dimond and Harries, 1984; Hatta and Dimond, 1984). Kwok et al. (2015) also found that the chin was touched most often (17.43 % of all sFST), closely followed by touches to the cheek (16.33 %), mouth (15.86 %) and hair (15.73 %). In two studies most touches were directed to the middle axis of the face. Mueller et al. (2019) found that 42.4 % of all sFST were directed to the middle axis of the face, though this effect was restricted to the retention interval. No such effects were found for other experimental phases (exploration and reproduction). Zhang et al. (2020) also reported that most sFST were directed to the middle axis of the face (M = 14.66 sFST/h) followed by touches to the hair (M = 7.83 sFST/h). One study reported that most sFST were directed to the nose (44.9 % of all sFST) (Johnston et al., 2014).

4.2.2. *Duration*

In five studies (DiMercurio et al., 2018; Dimond and Harries, 1984; Hatta and Dimond, 1984; Kwok et al., 2015; Zhang et al., 2020) the average duration of sFST was determined manually from the recorded

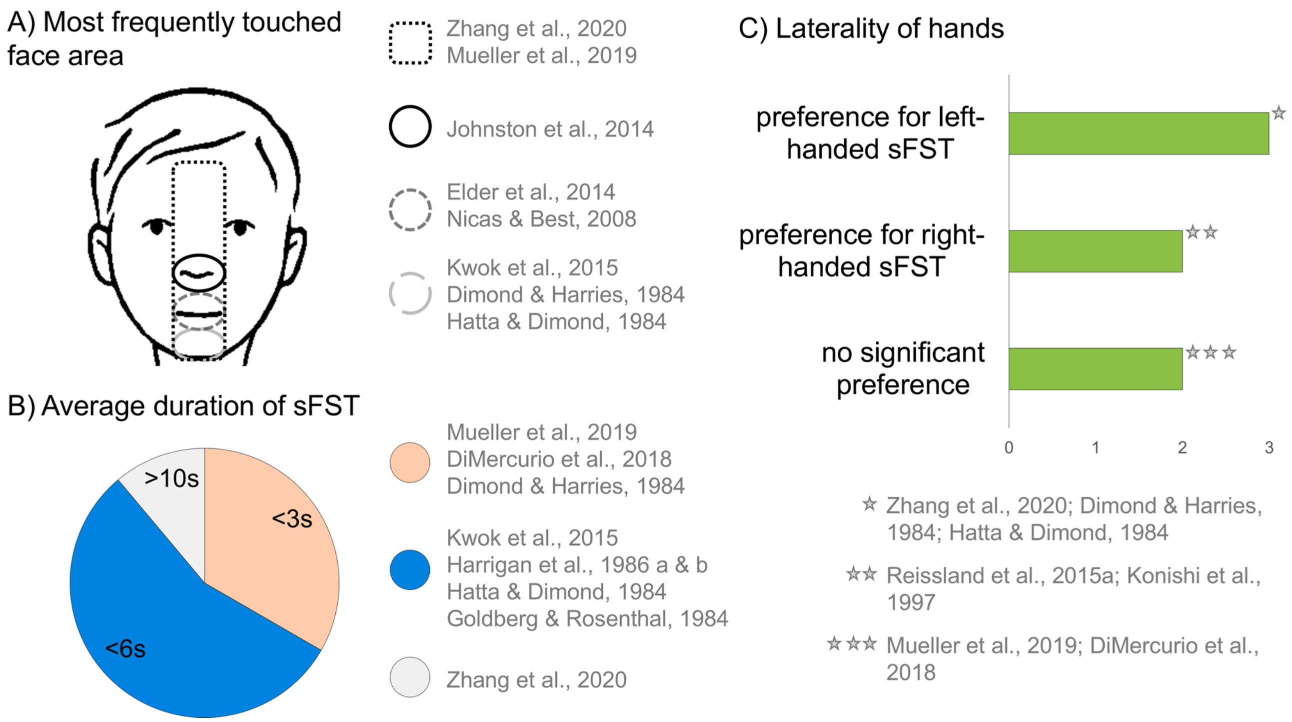

Fig. 2. Characteristic features of spontaneous facial self-touches (sFST). A) Schematic representation of which facial areas were touched most frequently (Adapted from Grunwald et al., 2014, Figure drawn by C. Maiwald). B) Average duration of sFST. C) Preference of hand use for sFST.

video material (M = 1.35, 2.8, 3.13, 5.89, 14.5 s). Zhang et al. (2020) reported that 42.2 % of all sFST were shorter than 3 s, 4.6 % lasted longer than 1 min and less than 0.2 % lasted longer than 5 min. Two studies additionally used EMG and tri-axial acceleration sensors to precisely register the movement patterns of participants and the temporal structure of sFST (Grunwald et al., 2014; Mueller et al., 2019). Mueller et al. (2019) divided the temporal structure of sFST into three phases: ST movement from the beginning of muscle contraction in the lifted forearm till contact between finger and face (T1, M = 0.91 s), duration of skin contact between finger and face (T2, M = 1.76 s) and duration of movement away from the face until the hand returned to a motionless resting position (T3, M = 0.98 s). There were no such precise codings of movement sequences in the other studies. Three studies used exclusion criteria for sFST lasting longer than five (Goldberg and Rosenthal, 1986) or four (Harrigan et al., 1986a,b) seconds; though no further analyses of temporal aspects of sFST have been conducted. One study found the duration of sFST to differ between left- and right-handed sFST (M = 2.29 and 0.42 s, respectively) (Dimond and Harries, 1984), whereas two other studies (Hatta and Dimond, 1984; Mueller et al., 2019) did not find any differences regarding duration and laterality. Zhang et al. (2020) observed that ipsilateral sFST (left hand touches left side of the face; right hand touches right side of the face) lasted longer than contralateral sFST (left hand touches right side of the face; right hand touches left side of the face). Mueller et al. (2019) found that contact duration (T2) and movement times (T1, T3) of sFST were significantly longer during memory retention when irrelevant acoustic stimuli interfered with the continuous maintenance of working memory load than during other experimental phases (T1: $t(29) = 2.878$, $p < .01$; T2: $t(29) = 2.477$, $p < .05$; T3: $t(29) = 2.668$, $p < .05$). So far, no other studies have attempted to examine situational changes of contact durations of sFST.

4.2.3. Laterality of hands

In seven studies, the laterality of the executing hand was determined when sFST were recorded. One study found a significant preference for left-handed sFST in British participants compared to Japanese while either listening to a lecture ($F(1,17) = 24.5$, $p < 0.001$) or without any assigned task ($F(1,17) = 46.91$, $p < 0.001$) (Hatta and Dimond, 1984). In another study the authors found a preference for left-handed sFST during all three conditions (no task, listening to music, listening to a lecture) (Dimond and Harries, 1984). Zhang et al. (2020) observed ST behavior of students in a graduate student office for five days. The authors found a preference for non-dominant (=left) hand-use in sFST. Mueller et al. (2019) found a marginally significant effect for the preference of right-handed sFST while participants had to perform a working memory task, relative to the total number of sFST. One study reported that there were no significant differences regarding laterality of sFST (DiMercurio et al., 2018). A long-term investigation of fetal movements reported a preference for right-handed sFST relative to the total number of all sFST (Reissland et al., 2015a). However, the results also revealed an inconsistent preference for hand use over the second and third trimester. Furthermore, the authors found that maternally reported stress level was significantly positively related to fetal left-handed sFST ($\chi^2 = 15.55(1)$, $p < 0.0001$). Another study investigated the laterality of different finger movements in preterms and found a preference for right-handed sFST (right-handed M = 1.45 sFST/min, left-handed M = 0.91 sFST/min) (Konishi et al., 1997).

4.3. Do attributes of the person influence the occurrence of sFST?

4.3.1. Age

Participants' age ranged from prenatal (Reissland et al., 2015a,b) to 82 years (Elder et al., 2014). Participants of all age groups showed sFST. To date the frequency of sFST relative to participants' age has only been examined for the age groups of fetuses up to the age of six (D'Alessio and Zazzetta, 1986; DiMercurio et al., 2018; Reissland et al., 2015b). Observations of fetal ST behavior (24−36 gestational week) revealed that the average sFST frequency decreased by four percent per week (Reissland et al., 2015b). Another study observed infants from their 3–13 week and found a constant frequency of sFST (M = 4.10 sFST/min) in the course of the observation period (DiMercurio et al., 2018). Rochat and Hespos (1997) analyzed newborns' head movements in response to spontaneous facial self-stimulation or external stimulation. The authors ascertained differences in the newborns' rooting responses (=head turns toward the stimulation with mouth open and tonguing) in relation to the participants' age: Newborns (age <18 h) displayed significantly more rooting responses following external compared to self-stimulation; four-week-old infants demonstrated an opposite pattern ($F(1,14) = 5.16$, $p < 0.039$). In one study younger children (2.8–3.4 years, M = 29 sFST/h) showed more sFST than older children (4.6–5.4 years, M = 15.8 sFST/h) (D'Alessio and Zazzetta, 1986).

4.3.2. Gender and sexual orientation

Sex effects of sFST have been analyzed in six studies (D'Alessio and Zazzetta, 1986; Goldberg and Rosenthal, 1986; Harrigan et al., 1986a,b; Knöfler and Imhof, 2007; Reissland et al., 2015a). One study indicated that girls had a preference for sFST compared to ST of other body parts (D'Alessio and Zazzetta, 1986). Three studies did not find any sex effects (Harrigan et al., 1986a,b; Reissland et al., 2015a). Two studies showed significant sex effects according to the sex composition of dyads (Goldberg and Rosenthal, 1986; Knöfler and Imhof, 2007). Goldberg and Rosenthal (1986) observed participants' ST behavior during a formal (job interview) and an informal (chat) situation and found that participants touched their face more under informal than under formal conditions. This effect of informality was relatively greater for applicants when the interviewer was male and for interviewers when the interviewer was female ($F(1,6) = 7.50$, $p = 0.034$). Knöfler and Imhof (2007) investigated the relationship between sexual orientation and sFST in dyads that were composed of individuals of the same biological sex. They found men to show more sFST than women during interpersonal communication if concordant dyads (both participants were heterosexual or both were homosexual) were observed ($\chi^2 = 5.41$, $p < .05$). Furthermore, the authors found sexual orientation to be associated with sFST: Male and female heterosexuals in mixed dyads (one heterosexual together with one homosexual participant) showed more sFST than heterosexuals in concordant dyads ($u = 7$, $p < .001$). No such difference was found for homosexual individuals.

4.3.3. Culture

Hatta and Dimond (1984) analyzed cultural differences of sFST. The authors found British participants to show significantly more sFST than Japanese while listening to a lecture ($F(1,17) = 5.54$, $p < 0.05$). Furthermore, British participants showed more left-handed sFST than Japanese participants did. British participants touched their chin most frequently (58 % of all sFST), whereas Japanese participants touched their nose most frequently (25 % of all sFST).

4.4. Explanatory models and attributed functions of sFST

4.4.1. Nonverbal leakage of negative affect

In three studies the occurrence of sFST was interpreted as a channel for expressing underlying negative affect (Goldberg and Rosenthal, 1986; Harrigan, 1985; Knöfler and Imhof, 2007). Consequently, feelings were not deliberately unveiled by participants but rather expressed in a physical form as sFST. The authors interpret sFST as a manifestation of underlying emotions such as uncertainty (Goldberg and Rosenthal, 1986), anxiety and tension (Harrigan, 1985) or awkwardness (Knöfler and Imhof, 2007). Goldberg and Rosenthal (1986) observed the ST behavior of participants (applicant and interviewer) during two situations: In the formal condition, an actual job-interview was conducted. In the informal situation, participants were told that there were "technical difficulties" and that they should "chat" for a few minutes. The authors found an increased frequency of sFST during the informal condition. Following their interpretation, participants might have been annoyed or uncertain due to the unexpected situation or they might have felt uncomfortable over increased levels of intimacy during a private chat. Analyzing interactions of physicians and their patients, Harrigan (1985) revealed that patients tend to display more sFST than physicians do. The author hypothesized that patients may experience feelings of anxiety or tension when making statements about their illness and emotions. Knöfler and Imhof (2007) found that heterosexual individuals in mixed dyads touched their faces more often than heterosexuals in concordant dyads did. The authors raised the question whether minor nonverbal cues by a homosexual partner solicited feelings of awkwardness, which caused the heterosexual partner to react with restless and nervous behavior, such as sFST.

4.4.2. Emotional regulation

Six studies discussed the causal link between the occurrence of sFST and emotions (D'Alessio and Zazzetta, 1986; Grunwald et al., 2014; Moszkowski and Stack, 2007; Mueller et al., 2019; Reissland et al., 2015a,b). However, these authors do not interpret sFST as a mere manifestation of underlying feelings, but rather attribute emotion-regulating functions to sFST. Only one study took neurophysiological data as a basis for explaining brain physiological effects of sFST (Grunwald et al., 2014), whereas the other studies' argumentation is based on behavioral data. One study used the still-face procedure and found that during the still-face period (mothers gaze at their infants, while maintaining an expressionless face), infants spent more time touching their faces than during normal interaction periods (Moszkowski and Stack, 2007). The authors suggest that infants used sFST to self-regulate their affective states when their mothers were unavailable as sources of external regulation. Reissland et al. (2015a,b), who found that maternally reported stress level was positively related to fetal sFST, likewise interpreted sFST as a mechanism of self-regulation. In one study younger children (age 2–3) displayed more sFST than older children (age 4–5) during free play (D'Alessio and Zazzetta, 1986). The authors suggested that the need of self-regulation significantly decreased with the emergence of a "competent-self" in older children. The assumption that sFST functionally serve as emotional regulation has been underpinned by neurophysiological data gathered in a study by Grunwald et al. (2014). In this study, participants completed a delayed memory task while listening to distracting aversive sounds. The authors found that the spectral theta power extremely decreased just before sFST. A significant increase of spectral theta and beta power was observed after sFST. The spectral theta changes imply that sFST are associated with cortical regulatory processes of emotions. Contrary to this, no significant changes were detected before and after instructed facial ST movements without cognitive or emotional load.

4.4.3. Cognitive functions: working memory regulation and attention focus

The neuro-physiological data of Grunwald et al. (2014) indicates that sFST may be involved in regulating working memory functions (Grunwald et al., 2014). The authors hypothesized that the increase of spectral theta power immediately after sFST represent processes of working memory maintenance. In addition the authors discussed cognitive focusing and attentional mechanisms to be associated with sFST. Mueller et al. (2019), who used the same experimental paradigm, found that most sFST were performed during the retention interval with distracting sounds compared to all other experimental phases (rest, exploration, reproduction) (Mueller et al., 2019). Furthermore, during the retention interval significantly more sFST occurred during the acoustic stimuli than during the silences between the sounds. According to the authors, this supports the assumption that sFST frequency increases when attention is distracted and needs to be refocused. Harrigan (1985) likewise discussed their results in the scope of cognitive processing and attention focus. According to the authors, the process of putting thoughts into words as well as focusing on the conversational content while simultaneously minimizing disturbance by interfering thoughts may be so complex as to incur an increase in sFST.

4.4.4. Emerging sense of self and body

Three studies discussed sFST within the scope of the developing sense of self or body (DiMercurio et al., 2018; Moszkowski and Stack, 2007; Rochat and Hespos, 1997). Rochat and Hespos (1997) found that newborns differed in their rooting responses depending on whether they displayed sFST or responded to external stimulation of their faces. The authors discussed the data as evidence for the ability to discriminate between self versus externally caused stimulation. DiMercurio et al. (2018) observed newborns and found a constantly high rate of sFST as well as other sST and touches of the surrounding environment (mattress). The authors mentioned that such activities are fundamental for developing an early sense of the body and the self by discriminating between their own body and the world around it. Moszkowski and Stack (2007) found that infants spent more time touching themselves when mothers were not available during the still-face phase. The authors hypothesized that sFST may be consistent with an exploratory function and discussed sFST in terms of sensorimotor experiences that have important implications for the development of infant's self-identity.

4.5. What are consequences of sFST-behavior?

One consequence of frequently touching one's own face is the risk of infection transmission of respiratory diseases. In this context, three studies focused on the frequency of sFST that were directed towards facial mucous membranes (eye, nose, mouth) and examined possible preventive behaviors (Elder et al., 2014; Kwok et al., 2015; Nicas and Best, 2008). Elder et al. (2014) asked participants about their self-reported prevention behaviors (i.e. trying not to touch one's eyes, nose or mouth with hands). Participants who stated they frequently avoided sFST actually touched their faces at the same rate as those who reported to only occasionally or rarely avoid touching their face ($M = 9.5$ and 10 sFST/h, respectively). Johnston et al. (2014) administered a survey to measure psychosocial predictors of sFST and found that the perceived severity of infection predicted lower rates of sFST. For every one-point increase in the severity scale (7-point Likert scale), workers had 0.41 fewer sFST/h ($r = -0.27$, $p < 0.05$). In another study, the sFST-behavior of medical students was observed while they attended a university lecture. Although they had completed an infection control course prior to the study, they touched their faces $M = 24$ sFST/h (Kwok et al., 2015). There was no control group where students were observed without having attended the infection control course before. Zhang et al. (2020) found that students touched their faces most often with the non-dominant hand while working in a graduate student office. The authors suggested to reinforce the differences in hand behavior in order to use the dominant hand for potential contaminated surfaces and therefore reduce the infection risk due to sFST. However, this assumption has not yet been further investigated. Nicas and Best (2008), who also found a high rate of sFST per hour ($M = 15.67$ sFST/h) developed an algebraic model for estimating the dose of pathogens transferred to facial mucous membranes. The model includes conditional variables for such a calculation, e.g. information about pathogen concentrations on room surfaces and pathogen die-off rates on the hands.

Another consequence in the context of sFST is that this behavior is visible to others and therefore might leave an impression on other people. Two studies investigated observer's impressions of physicians and patients who displayed either spontaneous, posed or no ST behavior (Harrigan et al., 1986a,b). In the first study the authors revealed that physicians and patients who displayed facial ST (spontaneous and posed) were regarded more demonstrative (composed of the six scales outgoing, dominant, expressive, friendly, interested, sociable) compared to participants who did not show any ST (Harrigan et al., 1986a). The results of the second study supported these findings: Individuals who displayed ST were regarded as more expressive (composed of the four scales expressive, dominant, outgoing, interested) and warm while control participants who did not show any ST were regarded as more calm (Harrigan et al., 1986b).

5. Discussion

The results of this review show that sFST are ubiquitous, as they were observed in all study settings: During social interaction (Goldberg and Rosenthal, 1986; Harrigan, 1985; Knöfler and Imhof, 2007; Moszkowski and Stack, 2007) or in the absence of others (Grunwald et al., 2014; Mueller et al., 2019; Nicas and Best, 2008); at work or while completing tasks (Elder et al., 2014; Grunwald et al., 2014; Johnston et al., 2014; Mueller et al., 2019; Nicas and Best, 2008; Zhang et al., 2020); during free play (D'Alessio and Zazzetta, 1986) or under more passive conditions such as sitting and listening (Dimond and Harries, 1984; Hatta and Dimond, 1984; Kwok et al., 2015). Participants of all age groups showed sFST: fetuses (Reissland et al., 2015a,b), newborns and infants (DiMercurio et al., 2018; Konishi et al., 1997; Rochat and Hespos, 1997), toddlers (D'Alessio and Zazzetta, 1986) and adults (Dimond and Harries, 1984; Elder et al., 2014; Goldberg and Rosenthal, 1986; Grunwald et al., 2014; Harrigan et al., 1986a,b; Harrigan, 1985; Hatta and Dimond, 1984; Johnston et al., 2014; Knöfler and Imhof, 2007; Kwok et al., 2015; Mueller et al., 2019; Nicas and Best, 2008; Zhang et al., 2020). They occurred independently of gender and in participants from all over the world (cf. Table 1). Spontaneous FST were performed with both the left and right hand and were directed towards different areas of the face. These results highlight the importance of understanding a behavior such as sFST that is a risk for infection transmission of respiratory diseases. Within the discussion we will explore whether sFST can or should be suppressed and how little we really do know about this peculiar behavior.

5.1. Trigger mechanisms and (regulatory) functions of sFST

Those studies that focused on trigger mechanisms of sFST found that sFST were associated with feelings of anxiety or tension (Harrigan, 1985), awkwardness (Knöfler and Imhof, 2007), uncertainty or uncomfortableness (Goldberg and Rosenthal, 1986), distressing situations (Moszkowski and Stack, 2007), need of self-comfort in social interaction (D'Alessio and Zazzetta, 1986) or maternally reported stress level (Reissland et al., 2015a,b). It is striking that negative emotional stimuli seem to trigger sFST in participants of all ages – from fetus to adult. Moreover, a recent study found significant associations between the number and duration of sFST with trait anxiety and dental anxiety (Carrillo-Díaz et al., 2021). The association of anxiety and ST has previously been demonstrated in research of sST of other body parts, but not explicitly for facial touch. One study observed that the number of sST in primates decreased after administration of anxiolytic medication (Schino et al., 1991). In another study, patients with alexithymia performed more ST than healthy participants (Troisi et al., 2000). Based on these findings it may be assumed that intense emotional states are associated with increased performance of sFST. In line with this, different arousal states have also been discussed as trigger mechanisms of sST (Harrigan, 1985). According to this, sST may occur more often during low arousal to increase it and during high arousal to evoke a down-regulation of arousal (Freedman, 1977; Scherer and Wallbott, 1979). Spontaneous ST may help reduce increased levels of arousal related to the experience of great pleasure, surprise or anxiety.

Some authors argue that sST are bodily manifestation of negative emotions (nonverbal leakage), which were not expressed through language and which the person may have tried to conceal from others (Goldberg and Rosenthal, 1986; Knöfler and Imhof, 2007). This explanatory approach was derived from nonverbal communication research of humans and primates (Ekman and Friesen, 1969b; Freedman and Hoffman, 1967; Rosenfeld, 1966). Other authors utilized explanatory approaches from earlier sST research that attributes emotion-regulating functions to sFST (D'Alessio and Zazzetta, 1986; Grunwald et al., 2014; Harrigan, 1985; Moszkowski and Stack, 2007; Mueller et al., 2019; Reissland et al., 2015a,b). According to this, sST occur after experiences of frustration, anxiety or fussiness and are involved in maintaining a homeostatic emotional state (Bard et al., 1990; Ruggieri et al., 1982; Tronick, 1989). On the other hand, SFST may be associated with cognitive load and attentional demands (Grunwald et al., 2014; Harrigan, 1985; Mueller et al., 2019). It is assumed that sST lead to a stronger focus of attention when coordination of complex cognitive processes is required (Barroso et al., 1980, 1978; Rögels et al., 1990). In line with this, Grunwald et al. (2014) and Mueller et al. (2019) found a higher rate of sFST when distracting sounds were presented during a delayed memory task. Regarding the functional aspects of sFST, it is currently unknown whether there are causal dependencies between attention, emotional processes or arousal. On the one hand, emotional processes could result in a distraction from an actual task and subsequently lead to sFST. One the other hand, distracted attention could lead to negative emotions, which in turn trigger sFST.

Most of these proposed triggers and interpretations are based solely on behavioral data. While various interpretations seem plausible, more experimental studies are required to gain substantiated insights. In the entire sST and sFST research there is only one study in which the function of sFST was examined on the basis of neuro-physiological parameters. Grunwald et al. (2014) found that sFST serve brain-regulatory functions and do not merely represent displacement activities. The authors' results indicate that spectral theta power differs shortly before and after sFST. A recent study using the same experimental setting was able to replicate these findings (Spille et al., 2021, submitted for publication). Which brain physiological processes take place during sFST and what exactly triggers sFST has not yet been clarified (see Fig. 3). Future research should make use of other biological markers such as heart or respiratory rate, pupillary reactions, or electrodermal activity in addition to EEG parameters to examine the regulation hypotheses of sFST. Investigating the neuro-physiological processes underlying spontaneous self-touch behavior may uncover new insights into self-regulatory mechanisms as well as emotional and attention processes.

5.2. Emerging sense of self and body by distinguishing between self-touch and touch by others

One hypothesis about the function of ST is that self-stimulation by touch may influence the early development of a sense of self and body (DiMercurio et al., 2018; Moszkowski and Stack, 2007; Rochat and Hespos, 1997). According to this, sFST, in addition to other tactile, haptic and proprioceptive stimuli, have been discussed to be of importance for the development of the distinction between self and others and for the development of a neural body representation (Holmes and Spence, 2004; Serino, 2019; Yamada et al., 2016). The development of a sense of self and body depends significantly on the multisensory integration of sensory information provided by touch, proprioception, vision and audition (Bremner et al., 2008). It is conceivable that both active and spontaneous ST provide similar somatosensory and proprioceptive feedback. Spontaneously touching a body part may still be different from actively exploring it. During sST, the attention focus on the produced sensory information might be lower compared to the active exploration of one's body or the active exploration of objects (Boehme et al., 2019). However, so far, comparisons of the sensory and neural processing of spontaneous and active FST are lacking. The hypothesis that sFST contribute to an emerging sense of self and body has been discussed in studies examining infants' touch behaviors (DiMercurio et al., 2018; Moszkowski and Stack, 2007; Rochat and Hespos, 1997). It remains unexplored however, in how far sST, and sFST in particular, may play a role in the maintenance of a sense of self and body later in life. Recent studies indicate an association of active self-touch with body ownership and body representation in adults (for review see (van Stralen et al., 2011)). Whether spontaneous FST have similar functions in adulthood remains unclear.

The development of a sense of self and body is also related to the ability of distinguishing between self-generated touch and touch by others (Rochat and Hespos, 1997). Rochat and Hespos (1997) found that newborns already respond differently to sFST and external face stimulation. A phenomenon that has been studied for years in the context of

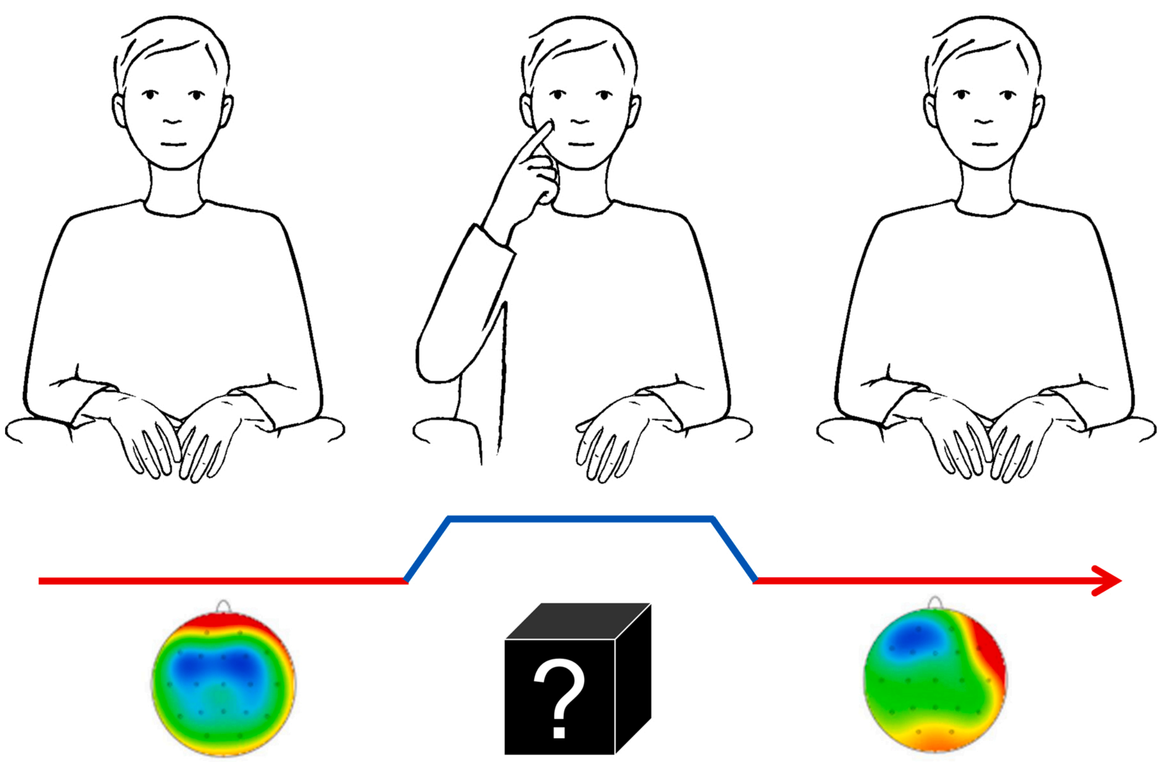

Fig. 3. Regulatory functions of sFST. Mean spectral power maps (EEG) show changes before and after spontaneous facial self-touch (sFST). Neuro-physiological triggers and mechanisms of sFST are largely unknown (Adapted from Grunwald et al., 2014, Figure drawn by C. Maiwald).

self-generated touch is called sensory attenuation (Blakemore et al., 1998; Kilteni and Ehrsson, 2020). In this, a self-generated stimulus is perceived as less intense than an identical externally generated stimulus, e.g., it is not possible to tickle oneself. It is assumed that internal forward models predict the somatosensory consequences of a movement based on a motor command and that these predictions attenuate the perception of the active touch (Blakemore et al., 2000). So far, this phenomenon has only been described in research on active, prompted ST (Boehme et al., 2019; Gentsch et al., 2015). Whether this phenomenon similarly occurs in sFST is unclear. The EEG study by Grunwald et al. (2014) suggests that there may be neurophysiological differences between active and spontaneous FST.

5.3. ST duration may increase with arousal, emotional or cognitive load

The results of the investigated studies show that sFST are predominantly of short duration. In three studies, the average duration of sFST was less than 3 s (DiMercurio et al., 2018; Dimond and Harries, 1984; Mueller et al., 2019) and in five studies less than 6 s (Goldberg and Rosenthal, 1986; Harrigan et al., 1986a,b; Hatta and Dimond, 1984; Kwok et al., 2015). Zhang et al. (2020) reported that 42.2 % of all sFST were shorter than 3 s, but on average sFST lasted 14.5 s. They also observed that 4.6 % of all sFST lasted longer than one minute. A frequently performed ST in this study was the act of resting the head on the hands during desk work. It is questionable whether such static and long lasting sFST are of the same nature as short sFST. Freedman and colleagues (Freedman, 1972) differentiated between discrete and continuous subtypes of ST. Discrete ST were described as short (3 s or less) and non-continuous, such as stroking the chin or touching the eyes (Freedman, 1972; Harrigan, 1985). Continuous ST last substantially longer (in some instances more than 100 s.) and are static (e.g. supporting the head) or dynamic (e.g. rubbing the forehead) (Freedman et al., 1973). Functions and mechanisms of continuous static or dynamic sFST in contrast to sFST of short duration have not yet been sufficiently studied. However, the investigated studies indicate that subtypes of sFST may be of different duration. Mueller et al. (2019) detected that sFST lasted significantly longer during memory retention than during haptic exploration or a drawing task. The authors speculate that the distracting sounds that were presented during the retention interval disrupted working memory maintenance. ST have been discussed to occur during emotionally or cognitively challenging situations (Freedman, 1972; Rögels et al., 1990). In line with this, ST duration may increase when emotional or cognitive load increases (Mueller et al., 2019) or when arousal de- or increases (Scherer and Wallbott, 1979). To date, there are no studies on potential neuro-physiological differences between long, short, static or dynamic sFST and what neuro-physiological functions different forms of sFST might have.

So far, studies on sST of other parts of the body have shown that the perception of sST by others seems to depend on the temporal dynamics of sST (continuous or discrete) (Harrigan et al., 1991, 1987). The authors argued that continuous ST are more common in depressed, paranoid, and schizophrenic patients and that such ST are therefore interpreted as signs of anxiety, negative affect or discomfort (Harrigan et al., 1986a). On the other hand, individuals were perceived as positive if they showed discrete sFST (Harrigan et al., 1986a,b). It is currently unknown whether the perception of discrete sFST differs from the perception of continuous sFST, but the results of the studies support the assumption that short sFST are of particular nature among all other sST.

Recently, touching movements to the body and the face have been investigated in association with affective social touch (Della Longa et al., 2019; McGlone and Reilly, 2010; Panagiotopoulou et al., 2017). Studies have shown that touch with specific velocity (1−10 cm/s) and pressure characteristics optimal for activating c-tactile cutaneous afferents is perceived as pleasant by the person receiving it (Löken et al., 2009). So far, there is only one study that tested the effect during active self-generated touch (Triscoli et al., 2017). Triscoli et al. (2017) found that active self-stroking (with an average velocity of 6.49 cm/s) was indeed perceived as pleasant. Yet, being stroked by the partner entailed the significantly highest pleasantness ratings and was the only condition that significantly decreased heart rate. Triscoli et al. (2017) discuss their findings in the context of sensory attenuation. We speculate that sFST might not be evaluated in terms of pleasantness since they are performed with little or no attention and it is difficult to remember them. It is currently unknown if sFST are performed with c-tactile specific velocity and pressure and whether they might impact heart rate or other autonomic functions. Previous literature relates increases in autonomic activity (such as heart rate and skin conductance) to increased emotional arousal (Codispoti and Cesarei, 2007; Malmstrom et al., 1965; Wulfert et al., 2005). Following the assumption that sFST serve to self-soothe (Reissland et al., 2015a,b; Moszkowski and Stack, 2007; Harrigan, 1985), this could be reflected in decreased autonomic activity. Thus, for future research, it is important to investigate biological markers in the occurrence of sFST of different durations and dynamics.

5.4. Left- or right-handed sFST – is there a difference?

Three studies observed a preference for left-handed sFST (Dimond and Harries, 1984; Hatta and Dimond, 1984; Zhang et al., 2020), two for right-handed sFST (Konishi et al., 1997; Reissland et al., 2015a) and two found no preference for hand laterality (DiMercurio et al., 2018; Mueller et al., 2019). Dimond and Harries (1984) found that the average duration of left-handed sFST was longer than right-handed sFST (M = 2.29 and 0.42 s, respectively). Mueller et al. (2019) found no such differences. Zhang et al. (2020) found that ipsilateral sFST lasted longer than contralateral sFST. Findings on hand laterality of other sST are inconsistent as well, but there is an observable tendency that hand laterality of sST is related to situational factors (Kimura, 1973; Ruggieri et al., 1982). This assumption has been discussed in the context of hemispheric activation in specific tasks or situations. A dominant right-hemispheric activation has been discussed to coincide with negative emotional states and the processing of verbal tasks that are accompanied by the performance of left-handed sST (Kimura, 1973; Ruggieri et al., 1982; Ulrich, 1977). A left hemispheric activation associated with right-handed sST is discussed in the context of geometric tasks and social anxiety during interpersonal contact (Kimura, 1973; Ruggieri et al., 1982). Future studies should investigate whether there are neuro-physiological differences between left-handed and right-handed sFST or of different facial areas.

5.5. Do physiological changes in the skin occur shortly before sFST?

Mueller et al. (2019) discussed the relevance of specific touched facial areas in connection with the sensory innervations of facial skin. They mentioned that skin areas above peripheral facial and trigeminal nerve communications should be considered as special points of interest, see Fig. 4. Anecdotally there seems to be an overlap of these skin areas and those where sFST are directed. The trigeminal system serves somatosensory (e.g., temperature or pain) and motor (e.g., biting and chewing) functions for the face and is part of the facial feedback of emotional expression (Haviland-Jones and Wilson, 2008). In a pilot study, an eight-week treatment with trigeminal nerve stimulation resulted in significant improvements of symptoms in patients with treatment-resistant unipolar depression (Cook et al., 2013). In the future, connections between the trigeminal nerve system and emotions should be investigated more explicitly. Furthermore, analyses should be performed of which specific face areas are touched and whether there is a connection with the sensory fields or the communicating branches of the trigeminal and facial nerve. EEG and other physiological changes when touching different parts of the face should be recorded. Future studies should also investigate whether there are top-down initiated dermal or other physiological micro changes of the skin that occur shortly before sFST. Harrigan (1985) already prompted the question if

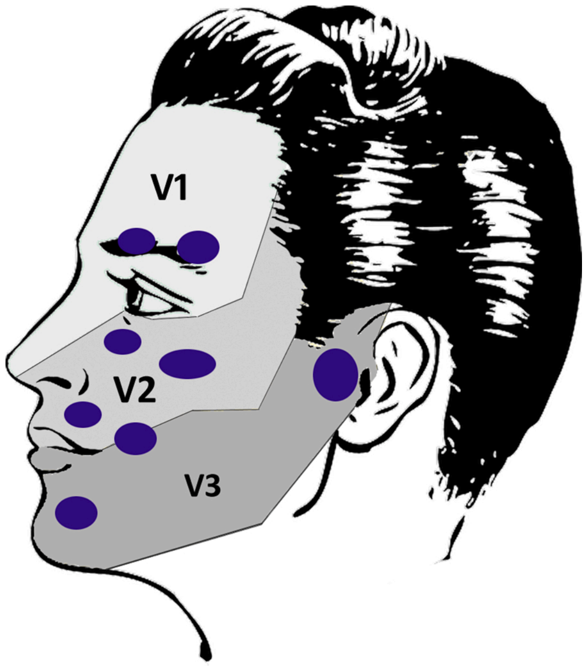

Fig. 4. Sensory innervation areas of the trigeminal nerve and areas of communicating rami of facial and trigeminal nerve. Innervation areas: V1 = ophthalmic; V2 = maxillary; V3 = mandibular branch of nervus trigeminus; gray dots: connections of superficial branches of trigeminal nerve and facial nerve. (Face by Clker-Free-Vector-Images). (Adapted from Mueller, 2019, CC BY 4.0).

the experience of feelings such as anxiety or tension may produce chemicals or changes in receptors in the area of the face and if these changes may stimulate itching sensations. However, previous research excluded sST that respond to local skin irritations such as itching (Dimond and Harries, 1984; Mueller et al., 2019). With the observational methods used so far, it is not possible to sufficiently prove what triggers sFST. Research on movement disorders such as tics and Tourette's syndrome indicates that patients perceive localized premonitory urges shortly before movements are performed (Patel et al., 2014). It should be clarified whether such urges also occur prior to the execution of sFST and in how far they are noticeable.

5.6. Are spontaneous touches to the face distinct from other forms of sST?

In previous research the occurrence and function of facial as well as other sST has been explained with the same models. However, in those studies which captured both sFST and touches of other body parts (torso, arms, hands, legs, feet), sFST were observed most frequently (D'Alessio and Zazzetta, 1986; Harrigan, 1985) or second most frequently (DiMercurio et al., 2018; Goldberg and Rosenthal, 1986). So far, no studies have addressed why the face is such a predominant goal. Recent insights into the connectivity between the cortical hand and face representations may provide a hypothetical approach. In one study, repetitive somatosensory stimulation of the fingers led to cortical and perceptual changes in the face but not in the forearm (Muret and Dinse, 2018). Another study showed that hand-mouth movements were represented as integrated synergies within the precentral gyrus (Desmurget et al., 2014). It should be clarified whether the proximity of the cortical representation of the hand and face is also associated with a functional coupling and whether this can provide information on why the face is touched more frequently than other parts of the body.

5.7. Can active facial ST result in similar effects as sFST?

In one study the investigator instructed the subjects to actively touch their faces (Grunwald et al., 2014). Actively touching one's own face did not result in the same EEG changes that occurred during spontaneously touching the own face. In the experiment, however, the examiner gave the instruction in the absence of additional tasks or stimulus presentations. Therefore, the question remains unanswered whether the active execution of facial ST could have regulatory effects in situations in which, for example, emotional or working memory processes are disturbed. It is known from embodiment research that adopting a certain posture can influence affective (e.g. (Barsalou et al., 2003)) and cognitive (e.g. (Strack and Neumann, 2000)) states. Future research should therefore investigate which psychological or neuro-physiological effects are associated with the active execution of facial ST under various conditions. Previous investigations of active ST focus on the neural processing and sensory attenuation effects of active self-touch in comparison to touch by others or by tools (Ackerley et al., 2014; Boehme et al., 2019; Gentsch et al., 2015; Hara et al., 2015; Tajadura-Jiménez et al., 2013; Triscoli et al., 2017). Those studies did not investigate emotion or cognition regulatory functions of ST.

5.8. Self-touch as a risk for transmission of infections – can we stop touching our face?

The analyses of all included studies revealed that most sFST are directed to the middle axis of the face: mouth (Elder et al., 2014; Nicas and Best, 2008), chin (Dimond and Harries, 1984; Hatta and Dimond, 1984; Kwok et al., 2015), nose (Johnston et al., 2014) and middle axis (Mueller et al., 2019; Zhang et al., 2020) were touched most frequently. These findings were discussed in the scope of the risk of indirect transmission of respiratory infections. In case of indirect transmission, infections can be transmitted by touching mucous membranes of the face after having touched contaminated surfaces (Gwaltney and Hendley, 1982). To stop touching mouth, nose and eyes is recommended to prevent infections (Elder et al., 2014). Johnston et al. (2014) found that perceived severity of infection predicted lower rates of sFST. However, Elder et al. (2014) found that medical staff who stated they frequently avoided touching their face actually touched it at the same rate as those who reported to only occasionally or rarely avoid touching their face. Hence the authors concluded that sFST are a habitual behavior that may occur unnoticed. This assumption was confirmed by a study that examined participants' accuracy in remembering their own nonverbal behavior after an interpersonal interaction and found that accuracy was lowest for sST, compared to other behaviors (e.g. nodding, gesturing) (Hall et al., 2007). In association with infection protection, it should be clarified if or how sFST-behavior can be effectively reduced.

Current studies are investigating the effectiveness of physical barriers such as wearing masks (Chen et al., 2020; Lucas et al., 2020; Shiraly et al., 2020) or applying tapes designed to prevent the execution of arm flexion that precedes sFST (Senthilkumaran et al., 2020). Heinicke et al. (2020) suggested behavioral strategies to reduce habitual hand-to-head behavior, which should entail awareness training and establishing competing responses. Research of tic suppression in patients with tic-disorders underline the relevance of mental effort and/or alternative active movements (Kawohl et al., 2009). The behavioral, cognitive and neuro-physiological effects of actively suppressing sFST should be investigated.

6. Limitations

The defined goal of the review was to analyze features, mechanisms and functions of sFST. In the selected studies different study designs and methodological procedures were used, which limits the evaluation of evidence. In 13 studies (D'Alessio and Zazzetta, 1986; DiMercurio et al., 2018; Goldberg and Rosenthal, 1986; Harrigan et al., 1986a,b; Harrigan, 1985; Knöfler and Imhof, 2007; Konishi et al., 1997; Kwok et al., 2015; Moszkowski and Stack, 2007; Nicas and Best, 2008; Rochat and Hespos, 1997; Zhang et al., 2020) video recordings were used to analyze sFST, in four studies (Dimond and Harries, 1984; Elder et al., 2014; Hatta and Dimond, 1984; Johnston et al., 2014) the ST behavior of the participants was observed live. Given that most sFST are of short duration, the accuracy of capturing temporal aspects of sFST under these observation methods is limited. Solely two studies used EMG sensors and triaxial acceleration sensors in addition to the video records in order to register the movement pattern of sFST with temporal accuracy (Grunwald et al., 2014; Mueller et al., 2019). Furthermore, the duration of observation per participant varied vastly in the studies and ranged from short observation periods (12 s (Harrigan et al., 1986a,b)) to long observation periods (M = 337 min (Johnston et al., 2014)). In one study, participants were observed over a total period of five twelve-hour days (Zhang et al., 2020). Short observation periods do not allow to assert whether the ST behavior of participants changes over time. Due to the complexity of factors and trigger mechanisms of sFST, researchers should consider sufficiently long observation periods for the investigation of sFST.

Furthermore, the studies showed large differences in the definition of sFST and the applied coding criteria. Harrigan et al. (1986a,b) did not capture sFST when they occurred together with other behavior (e.g., changes in posture or facial expressions, nodding, speaking, smiling). Mueller et al. (2019) excluded sFST from the analysis that had an obvious instrumental value (e.g., nose picking or scratching). In contrast, Elder et al. (2014) reported that at least 50 % of the observed sFST could be classified as nose picking or eye rubbing. The studies also applied different definitions of the facial areas to be examined. Four studies examined touches of the head without differentiating individual facial areas (D'Alessio and Zazzetta, 1986; DiMercurio et al., 2018; Harrigan, 1985; Reissland et al., 2015a). Statements about specific touched face areas cannot be made on the basis of these study results. Some studies explicitly recorded sFST of ears (Dimond and Harries, 1984; Kwok et al., 2015; Zhang et al., 2020) or hair (Goldberg and Rosenthal, 1986; Kwok et al., 2015), whereas in two other studies these same sFST were excluded from the analysis (Johnston et al., 2014; Mueller et al., 2019). D'Alessio and Zazzetta (1986) found that girls touched their hair more often than boys. This result cannot be clearly interpreted: The more frequent hair touching in girls could be explained by the fact that they have longer hair and therefore brush wisps of hair from their face or do their hairstyle. At the same time, this result cannot be compared to other studies in which sFST of the hair were excluded. Furthermore, the coding of temporal criteria of sFST is different in the selected studies. Six studies (DiMercurio et al., 2018; Goldberg and Rosenthal, 1986; Harrigan et al., 1986a,b; Moszkowski and Stack, 2007; Mueller et al., 2019) presented a minimum or maximum duration of sFST (> 0.33, .028 s or < 4, 4, 5, 10 s), whereas in the other studies, no time limits were applied to the acquisition of sFST. Zhang et al. (2020) recorded sFST that lasted longer than five minutes. It is questionable whether sFST of such different duration serve the same psychological or neuro-physiological purpose. The methodological differences of the studies make it difficult to make generally valid statements about sFST. To ensure comparability between studies, it is highly necessary to develop a coherent, reliable and valid coding system for sFST.

Furthermore, the studies were deficient in the reporting of relevant information. Six studies (Dimond and Harries, 1984; Goldberg and Rosenthal, 1986; Hatta and Dimond, 1984; Johnston et al., 2014; Kwok et al., 2015; Nicas and Best, 2008) did not report the participants' age and in one study (Kwok et al., 2015) information on gender distribution was missing. 13 studies did not or incompletely provide information about the encoders (D'Alessio and Zazzetta, 1986; Dimond and Harries, 1984; Grunwald et al., 2014; Harrigan et al., 1986a,b; Hatta and Dimond, 1984; Johnston et al., 2014; Knöfler and Imhof, 2007; Konishi et al., 1997; Kwok et al., 2015; Mueller et al., 2019; Nicas and Best, 2008; Rochat and Hespos, 1997). Missing information concerned the interraterreliability or whether the coders were trained in advance in the use of the coding system. In addition to a coherent coding system, reliable coding by trained personnel is essential for the precise acquisition of sFST.

The defined goal of the review was to investigate sFST as an independent phenomenon. With regard to the selection process, it is noticeable that more than 80 % of the studies did not meet the eligibility criteria for the review because the studies did not provide an exact definition of sST or pooled together sST of the whole body. It is possible that these studies include hidden results on sFST that have not been extracted because all body touches were considered together as one group of ST. The studies included in the review were characterized by the fact that ST of the head or face were an explicit object of investigation. However, due to a missing established terminology of sFST, studies that actually investigated sFST but used other terms may not have been identified by our search strings. Furthermore, due to the different and sometimes imprecise definitions of sFST in the studies, it is not possible to distinguish between spontaneous and instrumental (nose picking, tooth picking) facial ST at the outcome level. Within the studies that examined sFST as a possible risk of infection transmission, both spontaneous and active facial ST are relevant, since in both cases skin contact can lead to infection transmission. However, we assume that active instrumental facial ST differ from sFST in their neurophysiological functions and that instrumental ST may be more easy to control.

7. Conclusions

After having analyzed the current evidence, the question remains open which neurobiological and psychological functions sFST have. So far, researchers predominantly focused on descriptive approaches to sFST. Trigger mechanisms have been investigated, but remain unclear in detail. In order to understand functional differences of the distinct forms of sFST, a coherent coding system is needed that allows a detailed capture of sFST and facilitates distinction from other forms of ST. Moreover, neuro-physiological research methods are needed to further investigate the brain regulatory functions of sFST.

So far, the study setting of Grunwald et al. (2014) is the only one that is suitable to systematically trigger sFST in a controlled experimental setting. In the future, variations of the applied stimuli could contribute to a better understanding of sFST functions. In addition, behavioral and physiological outcome variables should be considered to confirm the regulatory hypothesis of sFST. Possible questions are: Do participants show better working memory performance when they execute sFST compared to conditions in which they are not allowed to touch their faces? Does heart rate or respiratory rate change before or after performing sFST? Do participants indicate that they feel calmer when they face touch - as opposed to a situation in which the execution of sFST is suppressed? Why do sFST occur when participants have nothing to do? With regard to the functional aspects of sFST, the causal dependence of the presumed factors of sFST needs to be clarified: Do disturbed emotional processes result in a distraction from the actual task and subsequently lead to sFST? Or are attention processes initially disturbed, which then lead to negative emotions, which in turn trigger sFST?

The idea of stopping sFST in order to prevent transmission of infections should be reconsidered. Spontaneously touching one's own face seems to be performed with little or no attention to its initiation or purpose. Moreover, sFST serve brain-regulatory functions. Maybe we should rather concentrate on washing our hands and wearing face masks – instead of intently trying not to touch our faces and deprive ourselves of the possibility of an inherent regulatory process.

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