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Towards a conceptual framework of adaptivity in face-to-face interaction: an interdisciplinary review of adaptivity concepts

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ABSTRACT

The pervasive phenomenon of adaptivity in face-to-face interaction is described inconsistently, using numerous concepts (e.g. alignment/attunement/complementarity/imitation/reciprocity/scaffolding/synchrony), impeding the streamlining of adaptivity research. We explored 33 adaptivity concepts and various adaptivity theories from different fields. We developed a theory-based conceptual framework consisting of two key dimensions. *Relatedness* refers to how people's actions should relate to each other to be considered adaptive and is described in terms of sameness (e.g. both friendly), oppositeness (e.g. dominant/submissive), or specified attentiveness (dissimilar acts). *Responsivity* refers to the timing of people's actions (sequential/simultaneous). The framework helps to understand what key elements adaptivity consists of. The framework can help transcending the concept and discipline level and examining and synthesizing research pertaining to adaptivity with similar dimensional characteristics.

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In face-to-face interaction, people constantly adapt to each other. Whether it is in everyday interactions between colleagues, family members, or between romantic partners, individuals are found to take parallel postures (e.g. Bernieri et al., 1988), become more similar in their accent (Giles et al., 1991), or show more similar affect over time (Nicely et al., 1999). Most roughly defined, adaptivity in interpersonal interaction refers to people's adjustments to each other (i.e. in cognitions, behaviour, and/or emotions). Adjustments in interactions indicate a situation of relating to or being in relation with someone else, meaning that the other matters in determining current states and future direction of a person. Interactions between people form the building blocks of development and learning (e.g. Vygotsky, 1978) and adaptivity is seen as 'a pervasive feature of social interaction' (Cappella, 1981, p. 123). Adaptivity has been considered a crucial qualification of interaction, in line with findings that adaptive interactions relate to more successful communication (Beebe et al., 2011; Bornstein et al., 2015; Ruusuvuori, 2001), more positive affect (i.e. perceived warmth and genuineness, Natale et al., 1979), feelings of affiliation, rapport and intimacy

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(Borrie et al., 2015), interpersonal satisfaction (Geerts et al., 1996), and development in language (Bornstein et al., 2015; Hwang & Windsor, 1999; Lohaus et al., 2006; Schertz et al., 2013), and cognition (Adamson et al., 2001; McGovern, 1990; De Graag et al., 2012).

To describe adaptivity in face-to-face interaction, however, a myriad of concepts (e.g. contingency, coordination, matching, imitation, reciprocity, responsiveness, and synchrony) and theories (e.g. Interpersonal Theory, Interactive Alignment Theory, Dynamic Systems Theory, Communication Adaptivity Theory) have been used (e.g. Burgoon et al., 2014). The multitude of concepts and theories that focus on adaptivity stress the significance of the phenomenon in a wide variety of relations and situations. At the same time, the multitude suggests that the phenomenon is not so easy to capture and conceptualize. Concepts themselves are not necessarily informative as they have not been consistently used to suggest fundamental qualifications or categorical distinctions with respect to adaptivity. And as Parsons et al. (2018) indicate: 'Such diverse terminology surrounding the same phenomenon impedes effective communication and, therefore, comprehensive understanding.' (p. 207).

For one, we see how *different* concepts are used to describe and empirically capture the *same* phenomenon. For example, Westerman (1990) used the term *maternal coordination* to describe how a parent adapts the level of instructional regulation to the degree to which the child manages to (un)successfully follow the parent's instructions. That is, the level of instructional regulation should be increased when the child fails and decreased when the child succeeds. Sun and Rao (2012) describe the same phenomenon using the term *scaffolding*. That is, they consider a mother's behaviour to be adaptive when the mother decreases instructional details after the child succeeds or when the mother increases instructional details when the child fails. In their study, Sun and Rao argue that 'Comparisons with existing research may enable a better understanding of the universal and culture-specific aspects of scaffolding and the relationship between adult scaffolding and specific cultural scripts.' (Sun & Rao, 2012, p. 114). Yet, the work of Westerman (1990) is not referred to, which would have been useful in getting a better insight into differences in mothers' adaptations between Western and Chinese cultures, which was the goal of Sun and Rao (2012). The fact that different concepts are used to describe the same phenomenon also has detrimental consequences for reviews. Reviews that focus on a single concept tend to overlook a substantive body of literature. Van de Pol et al. (2010), for example, focused on scaffolding or instruction that is adapted in its level of regulation to a student's understanding. In their review, they only included studies that use the concept of scaffolding, whereas many other studies – using other concepts – focus on the phenomenon under study by Van de Pol et al. (2010). One example is the study of Arnett (2003). As the concept of focus in Arnett (2003) is teacher adaptations, this relevant article is not included in the review of Van de Pol et al. (2010). And even reviews that have used several concepts, still overlook important literature. A valuable review by Parsons et al. (2018) focused on adaptive instruction but, for example, neglected literature using the term contingent teaching (which refers to the phenomenon under study). To be able to overcome such issues, researchers need to transcend the concept level and the current study helps to do so by developing a theory-based conceptual framework.

In addition, we see how the *same* concept is used to describe *different* empirical phenomena. Lunkenheimer et al. (2013), for example, used the term *contingency* to describe a situation in which a child complied directly after a mother's directive, whereas Lohaus et al. (2005) used *contingency* to describe a situation in which a mother's smile was followed by an infant's smile or vice versa. Although these authors did not suggest that they are referring to the same phenomenon (there are no references to the work of Lohaus et al. (2005) in Lunkenheimer et al. (2013)), using a single concept for different phenomena can be confusing. Complicating the matter even further, adaptivity concepts are not always consistently connected to or framed by theories and there are many different theories that address (aspects of) adaptivity. This lack of theoretical synthesis hampers a coherent understanding of the phenomenon.

We assume that the variety of empirical studies employing various adaptivity concepts may help to shed light on different core aspects of the phenomenon of adaptivity. By scrutinizing how studies – using a wide range of concepts to refer to adaptivity in face-to-face interaction – conceptualize and

operationalize adaptivity, and substantiate these choices with theory, we aim to get a better understanding of the phenomenon of adaptivity. Our main aim is to develop a conceptual framework that describes core dimensions of adaptivity and that is grounded in a synthesis of adaptivity theories; that is, a framework helps to understand what key elements adaptivity is composed of. In addition, the framework helps to position the type of adaptivity one is interested in and see in what ways it is similar or different to other types of adaptivity. Thus, we do not aim to provide one single overall conceptualization of adaptivity nor do we suggest that all researchers should start to use the term 'adaptivity.' Rather, we aim to develop a theory-based conceptual framework that: (1) describes the key aspects of adaptivity and thus helps to understand the phenomenon, (2) can serve as a tool for researchers from different fields to carefully think about the conceptualization of the phenomenon of interest, and (3) subsequently helps to determine what other research (even when using other concepts) is or is not relevant, which is important both in conducting single empirical studies and reviews or meta-analytic studies. The framework helps to transcend the concept level and connect research that pertains to adaptivity with the same dimensional characteristics (instead of including only research of a particular concept). We chose the term adaptivity as an overarching term here as it is rather general and encompasses various specific terms used by researchers in different fields.

To the best of our knowledge, no review is available that has endeavoured to develop a conceptual framework based on so many adaptivity concepts and wide variety of theories. Existing reviews often focus on describing effects of the phenomenon on one or several outcome measures, using a single concept (e.g. Mesman et al., 2009; sensitivity; Van de Pol et al., 2010; scaffolding), or using several concepts from one discipline (e.g. Harrist & Waugh, 2002; Parsons et al., 2018). Furthermore, Burgoon (e.g. Burgoon et al., 1995; Burgoon et al., 2017) included several adaptivity concepts in her important work on adaptivity in interpersonal relationships, but focused on distinguishing several concepts rather than on describing the essence of adaptivity. Although defining several concepts more precisely is important and the work of Burgoon has brought the field forward, our aim is to transcend the concept level and to explore a wide variety of adaptivity concepts and theories to distil the essential aspects of adaptivity. In this way, we seek to get a better understanding of the phenomenon of adaptivity in face-to-face interaction by synthesizing different aspects of different adaptivity concepts and adaptivity theories from different situations and different research areas (Communication, Education, Health Care, Linguistics, Clinical/Social/Developmental/Personality Psychology, Psychiatry, and Sociology) into core dimensions of adaptivity. The identification of general adaptivity dimensions, resulting in a theory-based conceptual framework, may allow researchers to address the same fundamental issues when conducting and substantiating research on adaptivity in face-to-face interaction, thereby facilitating further streamlining of adaptivity research. Accordingly, we hope the conceptual framework will spur further development and sharing of knowledge on adaptivity in face-to-face interaction across different contexts and disciplinary fields.

Method

This review can be classified as a scoping review that, in contrast to systematic reviews: (1) maps a broad topic area rather than address a specific question, (2) gives an overview of a large and diverse body of literature rather than a small and focused sample of studies, and (3) does not assess the selected study for bias risk (cf. Arksey & O'Malley, 2005).

Article selection and initial coding

Step 1: selection of adaptivity concepts

The goal of this step was to select all concepts that pertain to adaptivity in face-to-face interaction. We selected concepts based on an expert enquiry, pilot searches, and snowball sampling.¹ This resulted in 42 concepts (Table 1).

Table 1. Concepts of adaptivity, number of total and analysed hits, number of adaptivity indicators and number of cells of the conceptual framework (see Tables 3 and 4) in which the adaptivity indicators occur.

Search term	Concept	No. of hits ^a	No. of analysed hits (%) ^b	No. of adaptivity indicators ^c	No. of cells in conceptual framework (max = 7) ^d
adapt*	adaptivity/adaptive teaching	1425	15 ^e (1.05%)	28	5
align*	alignment	142	16 (11.27%)	30	5
attun*	attunement	48	13 (27.08%)	32	7
bidirectional*	bidirectionality	73	4 (5.48%)	15	2
calibrat*	calibration	26	1 (3.85%)	1	1
co-construct*	co-construction	77	3 (3.90%)	5	3
co-creat*	co-creation	49	0 (0.00%)	0	0
complement*	complementarity	245	16 (6.53%)	31	6
congruen*	congruency	232	2 (0.86%)	4	2
connectedness	connectedness	79	0 (0.00%)	0	0
contingen*	contingency	441	16 (3.63%)	59	5
coordin*	coordination	561	16 (2.85%)	33	5
co-regulat*/coregulat*	coregulation/co-regulation	34	16 (47.06%)	32	5
differentiat*	differentiated instruction	367	0 (0.00%)	0	0
echo*	echoing	47	3 (6.38%)	5	1
enmesh*	enmeshment	5	0 (0.00%)	0	0
entrain*	entrainment	62	5 (8.06%)	42	2
fit	fit	331	1 (0.30%)	1	1
harmon*	harmony	123	1 (0.81%)	1	1
imitat*	imitation	320	16 (5.00%)	52	2
individual* instruct*	individualized instruction	6	0 (0.00%)	0	0
interdependen*	interdependence	191	2 (1.05%)	8	2
intersubject*/inter-subject*	intersubjectivity/inter-subjectivity	171	11 (6.43%)	25	6
joint attention/joint engagement	joint attention/joint engagement	113	16 (14.16%)	29	4
match*	matching	398	16 (4.02%)	33	5
mimicry*	mimicry	83	7 (8.43%)	29	2
mirror*	mirroring	88	5 (5.68%)	6	3
mutual*	mutual adaptation/mutuality	284	14 (4.93%)	34	4
negotiat*	negotiation	802	1 (0.12%)	4	1
personali* instruct*	personalized instruction	2	0 (0.00%)	0	0
reactiv*	reactivity	561	4 (0.71%)	6	2
reciproc*	reciprocity	528	15 ^e (2.84%)	25	4
responsiv*	responsiveness	504	16 (3.17%)	40	5
rhythmic*	rhythmicity	98	3 (3.06%)	4	2
scaffold*	scaffolding	224	14 (6.25%)	33	5
sensitiv*	sensitivity	978	10 (1.02%)	15	4
shar* think*	shared thinking	2	0 (0.00%)	0	0
similar*	similarity	912	4 (0.44%)	7	1
student-cent*	student-centered instruction	25	0 (0.00%)	0	0
symmetr*	symmetry	95	0 (0.00%)	0	0
synchron*	synchrony	503	16 (3.18%)	21	5
uptak*	uptake	109	9 (8.26%)	12	1
Column totals		11.364	307 (27.02%) ^f	702	

^aThis refers to the number of articles that our search yielded, per concept.^bThe number of articles that we selected, based on our selection criteria. This is 0 when no articles met our criteria; if 0, the concept does not occur in the conceptual framework.^cMany articles contained more than one adaptivity indicator; we made one schematic summary for each indicator.^dThis refers to the number of cells in our adaptivity framework in which each concept occurs.^eFor adapt, the total number of articles is 15, not 16, because in our first selection round, we only found 14 relevant articles. In the validation check selection, we added only 1 article for each concept, resulting in a total of 15 articles. For reciproc, we also selected 15, but these were all selected in the first selection round. In the validation check selection, we did not encounter any relevant articles.^fThis refers to the average percentage of relevant hits compared to the total number of hits.

Step 2: literature search

With this step, we aimed to search for literature on each of the selected adaptivity concepts. We used databases representing disciplines in which interaction in face-to-face settings plays a role: Educational Resources Information Centre (ERIC), Modern Language Association International Bibliography (MLA), PsycINFO, and Linguistics and Language Behaviour Abstracts (LLBA). We conducted a search per concept. We restricted our search to peer-reviewed English publications and hits were included if the title and abstract contained the target concept and the title or abstract contained the search term *interact**. The searches resulted in 11.364 hits. References of all articles included in this review, including articles that are not directly referred to in this article, can be found in supplemental material C. All articles that are directly referred to in this article, can be found in the References section (articles that are part of the scoping review have an *).

Step 3: article selection

After having searched for the relevant literature, we wanted only select those articles that actually addressed adaptivity in face-to-face interaction. The main selection criteria were: the article (1) concerns face-to-face human interaction, (2) focuses on participants' cognitions, behaviour, and/or emotions as displayed in interaction,² (3) is empirical, and (4) is available to us. If an article could be excluded based on one selection criterion, we stopped checking the other criteria.

We scanned a random selection of 100 articles per concept, applying these selection criteria. As soon as we arrived at 15 relevant articles, we stopped scanning. If the 100 articles did not yield 15 relevant hits, we selected another 100 articles from the remaining articles until we had selected 15 relevant hits. If still less than 15 hits were selected, we did subsequent selection rounds until all hits were scanned. For several concepts, less than 15 relevant hits were identified in the total hits resulting from our search (e.g. attun, bidirectional). For those concepts, we only selected the relevant hits. See Table 1 for an overview of the search results and selections made.

The aim of this scoping review was not to give an exhaustive overview of all the literature. In addition, scanning all hits ($N = 11.364$) and reading all relevant hits would not be feasible (also see Levac et al., 2010). Therefore, we used a saturation procedure (Boeije, 2009) to get an indication of whether the articles selected give a good overview of the adaptivity concepts or, if no saturation occurred, whether some concepts were too diverse to yield an coherent picture (see section 'Core Dimensions'). In this initial article selection phase, 271 relevant articles were selected (max. 15 per concept). For nine concepts, none of the articles met the inclusion criteria (cf. Table 1); those concepts thus do not occur in the conceptual framework. To determine interrater reliability, 105 articles were scanned independently by two researchers. Interrater reliability was calculated for inclusion/exclusion (dichotomous) using the agreement coefficient AC1 (Gwet, 2008) and percentage of agreement using the *agreestat* function (<http://www.agreestat.com>) for R (Version 3.2.2). The interrater reliability was good, $AC1 = 0.85$ and average percentage of agreement was 90%. The pairwise comparisons of raters revealed a range of interrater reliability of 0.66–1.00 for AC1 and 84–100% agreement, which can be considered substantial to (almost) perfect (Landis & Koch, 1977).

Step 4: coding articles

To make the abundance of information manageable, we coded the selected articles using a code-book (supplemental material A) focusing on, amongst others, the used theory/theories and the definition/description and/or operationalization of the adaptivity concept. In addition, we summarized the definition/adaptivity description/operationalization of the adaptivity concept in a schematic summary (see Table 2 for examples and supplemental material B for all schematic summaries and notation conventions).

If several adaptivity indicators were used in one study, these were analysed separately when they were also measured separately in the article. For example in Ruusuvuori (2001) doctors' behaviour was considered adaptive when either the doctor oriented to the patient, followed by the patient

Table 2. Examples of schematic summaries.

Article and concept	Time-point 1	Time-point 2	Time-point 3
Scaffolding (Sun & Rao, 2012)	PROPORTION Mother _{instruction with guidance level X} → Child _{success} → Mother _{instruction with guidance level X-1}		
Parental scaffolding (Evans et al., 2003)	PROPORTION Parent _{instructional demand level X} → Child _{succeeds} → Parent _{instructional demand level X-1}		
Dyadic matching (Noe et al., 2015)	DURATION (Infant _{ffective behavioural state x∞} WHILE Mother _{ffective behavioural state x∞})		
Coordin (Ruusuvuori, 2001) ^a	Doctor _{orients to X}	↔ Patient _{orients to}	↔ ∞
	Doctor _{orients to X} WHILE Patient _{orients to X}		

^aIn this article, two adaptivity indicators were used.

Note. The conventions for making the schematic summaries can be found in Supplemental Material B.

orienting to the doctor (which could continue for more than two time-points), or when the doctor and patient oriented to each other simultaneously (hence ‘WHILE’ in the schematic summary). In this case, we distinguished two adaptivity indicators (see Table 2). For each adaptivity indicator ($N = 702$), we created a separate summary. To establish interrater reliability, four researchers coded 10 randomly selected articles from 10 randomly selected concepts. Given that the codes involved providing descriptions (e.g. of the theory/theories used or the definition of adaptivity used), we could not calculate regular interrater reliability measures. Instead, the descriptions of the four coders that were made with the codebook about the 10 randomly selected articles were compared and we agreed on a final answer. Then, we compared each coder’s answer to the final answer and calculated the percentage agreement ($M = 77.4\%$; range 67%–90%).

Core dimensions

To discern core dimensions of adaptivity, we first made the available information more manageable by combining schematic summaries within concepts that were similar. Summaries were combined when: the actions were similar, the arrows were in the same direction (e.g. one-sided or double-sided), and the number of time-points was the same. In some articles, a time-lapse between time-points was specified (e.g. there was good fit if the child looked towards the object within three seconds after the parent looked at the object). We did not take these time-lapses into account when combining similar summaries. Also, the type of actor and partner could differ (e.g. mother and child in Sun and Rao (2012) or doctor and patient in Ruusuvuori (2001) in Table 2). In deciding whether two summaries could be combined, we additionally consulted the descriptions in the codebook for each concept (Supplemental material A). For example, the summaries of Sun and Rao (2012) and Evans et al. (2003) in Table 2 were combined into one because the actions were similar, the arrows were in the same direction, and the number of time-points was the same.

By systematically comparing each combined summary with all other combined summaries and recording the similarities and differences between the conceptualizations of adaptivity represented by those summaries, we aimed to understand shared and distinct features of different conceptualizations of adaptivity. Each combined summary of all concepts was compared to all the combined summaries of the other concepts. For example, for joint attention/engagement, we could discern six combined summaries within the 15 relevant articles for this concept; for coordination, we could discern three combined summaries. We compared the first summary of joint attention/engagement with the first summary of coordination, the first of joint attention/engagement with the second of coordination, etc., until all between-concept comparisons were finished for all concepts. In making these comparisons, we recorded the similarities and differences we saw between two summaries. A difference between the summary of Noe et al. (2015) and Evans et al. (2003) is, for example, that in Noe et al. (2015), the same actions within the infant and the mother are

compared (i.e. a given affective state) while in Evans et al. (2003), different actions of the parent and child are compared (i.e. the parent’s instructional demand level and the child’s failure). Therefore, *similarity of actions* was added as a bottom-up code.

To distil the essence of adaptivity, our last step was to compare and integrate all bottom-up codes (cf. selective coding, Boeije, 2009) leading to two key dimensions on which concepts differed. Those key dimensions were synthesized into our conceptual framework. The similarity of actions, for example, was subsumed under the sameness subtype of the relatedness dimension. Comparisons and integrations of bottom-up codes were done by the first author and were checked by another author. Inconsistencies were resolved through discussion. For each concept, we selected articles in three rounds. We started with a selection of five (or less if fewer than five articles were available) articles (random selection of the 15 (or less) relevant articles available). We decided that there was saturation when four of the five articles had the same adaptivity description, while also referring to the same actions (this only happened for complement* and scaffold*). If this was not the case, we did a second round with a selection of five articles (if available) and decided that there was saturation when at least 8 of the 10 articles had the same adaptivity description, while also referring to the same actions (this was only the case for uptak*). If this was not the case, we did a third round with a selection of five articles (if available) and decided that there was saturation when at least 12 of the 15 articles had exactly the same adaptivity description, while also referring to the same actions (for none of the concepts there was saturation). If, after this third round, no saturation was reached, we stopped: the adaptivity descriptions were apparently too diverse within a concept; another round of coding was not likely to result in saturation.

Positioning of concepts in conceptual framework

To be able to describe to what extent each concept is defined (un)ambiguously in the literature, we next placed all concepts (that is, all indicators used for the concepts) in the conceptual framework (see Results, Table 3 for the framework and Table 4 for how the indicators are placed within the framework). To establish interrater reliability, two of the authors independently placed 12% of the adaptivity indicators into the framework. With a Krippendorff’s alpha of .78, the interrater reliability was considered substantial (Krippendorff, 2004).

Adaptivity indicators that could not be placed in one single cell of the framework, were placed into a mixed/other category (only 7% of the cases). This pertains to cases in which one measure was used for adaptivity while adaptivity can be reached in several ways that do not point to the same dimensions in our framework. In that case, we categorized the fit type as ‘mixed.’ An example is Gratier (2003), where adaptivity was established when (1) the mother’s and infant’s vocalizations overlap with matching pitch (i.e. at exactly the same time-point) or (2) when ‘one of them continues the other’s vocalization, completing a coherent pitch contour’ (p. 546). Both cases (overlap with matching pitch and continuing of the other’s vocalization completing a pitch contour) were seen as adaptive and subsumed under the same overarching measure of adaptivity used in the study of Gratier (2003).

As a validation of our conceptual framework (referred to as ‘validation check’ in a footnote of Table 1), we selected one more relevant article per concept (if available), resulting in a maximum number of 16 selected articles per concept (a total of 36 articles were selected here, see Table 1).

Table 3. Conceptual framework of adaptivity in face-to-face interaction.

		Responsivity	
		Reactivity	Co-occurrence
Relatedness	Sameness Oppositeness Specified attentiveness		
Mixed/Other			

Note. The framework consists of two main dimensions: Relatedness and Responsivity, which are each divided into sub dimensions. Each cell denotes an adaptivity type.

Table 4. Placement of concept indicators in the conceptual framework of adaptivity in face-to-face interaction.

		Responsivity									
		Reactivity					Co-occurrence				
Relatedness	Sameness	Adapt ^{3/3}	Align ^{14/10}	Attun ^{6/3}	Bidirect ^{10/3}		Adapt ^{13/7}	Align ^{9/4}	Attun ^{10/7}	Co-constr ^{1/1}	
		Coord ^{14/5}	Compl ^{7/5}	Congr ^{1/1}	Cont ^{34/11}		Compl ^{4/3}	Congr ^{3/1}	Coord ^{15/12}	Coreg ^{14/}	
		Coreg ^{15/7}	Echo ^{5/3}	Entrain ^{27/5}	Imitat ^{50/17}		Entrain ¹¹	Entrain ^{15/2}	Inter-sub ^{13/6}	Joint ^{16/10}	
		Interdep ^{6/2}	Intersub ^{1/1}	Joint ^{2/2}			Match ^{13/9}	Mimic ^{26/4}	Mirror ^{2/1}	Mutual ^{7/6}	
		Match ^{15/7}	Mimic ^{3/3}	Mirror ^{1/1}	Mutual ^{13/5}		Recipr ^{5/5}	Respons ^{4/1}	Rhythm ^{3/2}		
		Negotiat ^{4/1}	Reactiv ^{4/2}	Recipr ^{15/9}			Scaffold ^{1/1}	Sensitiv ^{1/1}	Similar ^{7/4}		
		Respons ^{5/3}	Scaffold ^{4/3}	Sensitiv ^{3/1}			Synchr ^{10/10}				
		Synchr ^{2/2}					Total: 192/108				
	Oppositeness	Total: 264/115					Adapt ^{4/3}	Attun ^{1/1}	Compl ^{4/4}	Coord ^{1/1}	
		Adapt ^{1/1}	Attun ^{2/1}	Align ^{1/1}	Intersub ^{1/1}		Match ^{2/2}	Synchr ^{1/1}			
		Coconstr ^{2/1}	Compl ^{7/6}	Cont ^{1/1}	Interdep ^{2/1}		Total: 13/12				
		Joint ^{2/2}	Scaffold ^{2/1}								
	Specified attentiveness	Total: 21/16					Adapt ^{7/5}	Align ^{5/3}	Attun ^{2/2}	Bidirect ^{5/3}	
		Calibrat ^{1/1}	Coconstr ^{2/2}	Coord ^{2/1}	Compl ^{1/1}		Attun ^{7/2}	Cont ^{1/1}	Coreg ^{1/1}	Intersub ^{4/3}	
		Cont ^{21/7}	Coreg ^{1/1}	Fit ^{1/1}	Intersub ^{3/2}	Joint ^{9/4}	Match ^{1/1}	Recipr ^{1/1}	Respons ^{2/1}		
		Mutual ^{9/3}	Reactiv ^{2/2}	Respons ^{27/11}			Total: 17/10				
Mixed/ Other		Scaffold ^{24/13}	Sensitiv ^{9/8}	Synchr ^{2/1}							
		Uptake ^{12/9}									
		Total: 145/80					Align ^{1/1}	Attun ^{4/4}	Compl ^{3/3}	Cont ^{2/2}	
		Coord ^{1/1}	Coreg ^{1/1}	Harmon ^{1/1}	Imitat ^{2/1}		Coord ^{1/1}	Coreg ^{1/1}	Harmon ^{1/1}	Imitat ^{2/1}	
		Intersub ^{3/3}	Match ^{2/1}	Mirror ^{3/3}	Mutual ^{5/3}		Intersub ^{3/3}	Match ^{2/1}	Mirror ^{3/3}	Mutual ^{5/3}	
		Recipr ^{4/4}	Respons ^{2/2}	Rhythm ^{1/1}	Scaffold ^{2/1}		Recipr ^{4/4}	Respons ^{2/2}	Rhythm ^{1/1}	Scaffold ^{2/1}	
		Sensitiv ^{2/2}	Synchr ^{6/5}								
		Total: 45/39									

Note. The first superscript number refers to the number of adaptivity indicators belonging to the concept; the second superscript number refers to the number of articles from which the adaptivity indicators of this concept stem.

We coded these articles, compared the summaries of these articles to all other summaries and checked whether we encountered new similarities and differences and whether adding these articles would yield new or change existing core dimensions (which was not the case). We could place the adaptivity indicators from these articles in our conceptual framework which validated our framework. The final number of articles included in this review is 307 (271 from the initial article selection phase + 36 from the validation check).

Results

Adaptivity dimensions

All included studies provided, explicitly or implicitly, norms for determining when interaction is adaptive and we encountered a wide variety of norms used to conceptualize adaptivity. Lunkenheimer et al. (2011), for example, considered actions to be adaptive (i.e. co-regulated) when a parent and his/her child simultaneously showed high positive affect intensity. Denham (1993) considered actions to be adaptive (i.e. responsive) when a mother responded with calm neutrality or cheerful displays upon her child's angry actions.

Scrutinizing the variety of conceptualisations of adaptivity, we concluded that they differed on two key dimensions (Table 3). First, they differed in their conceptualization of the appropriate way people relate to one another in a given situation (i.e. *relatedness*). That is, articles differed in what combination of actions are compared in determining adaptivity: actions that are exactly similar, actions that are opposite, or a specific combination of actions that are different but not opposite. Second, the conceptualisations differed in how this relation is established by people being responsive to one another (i.e. *responsivity*) or in other words, the timing of people's actions (e.g. actions should be sequential or actions should co-occur).

Relatedness

Relatedness refers to how people's actions should relate to each other in order to count as adaptive. Sometimes, people's actions are seen as adaptive when the actions are the same (i.e. sameness). Other times, people's actions are seen as adaptive when the actions are opposite to each other (i.e. oppositeness). Finally, sometimes people's actions are seen as adaptive when the actions are dissimilar but not opposite (specified attentiveness).

For the majority of the adaptivity indicators (66%), relatedness was considered in terms of *sameness* in peoples' actions. That is, actions were considered adaptive when people show the same actions in terms of a particular quality (e.g. friendly-friendly). Examples are a mother repeating the phrase of her child (Tarplee & Barrow, 1999) or a lawyer using the same vocal intensity as the judge (Beňuš et al., 2014).

Second, people's actions were occasionally (5%) considered related when there was *oppositeness* between them. That is, when people show opposite actions in terms of a particular quality, their interaction was characterized as an adaptive one. One person being dominant and another being submissive (e.g. Ma & Dubé, 2011) is an example of the oppositeness type of relatedness. Note that both sameness and oppositeness can occur simultaneously when considering different qualities of people's actions; a teacher could be both friendly and dominant while a student is friendly (sameness) and submissive (oppositeness). Interpersonal Theory (19 studies), Interactive Alignment Theory (11 studies), and Communication Adaptation Theory (8 studies) substantiate the sameness and oppositeness type of relatedness. Interpersonal Theory provides a clear, context-independent norm of adaptivity and this norm was used in the same way throughout these studies. Studies using Interpersonal Theory (for the concepts adaptation, complementarity, interdependence, and mimic) most often referred to the Circumplex Model (e.g. Kiesler, 1983), which conceptualizes interpersonal behaviour in terms of agency and communion dimensions. This model states that: '(1) in general, dyadic behaviours on both dimensions elicit or constrain each other in a complementary manner, and (2) complementarity has predictable influence on interaction outcome.' (Ma & Dubé, 2011, p. 84). On the agency dimension, there is adaptivity when one person acts in a dominant way while the other person acts in a submissive way (= oppositeness). On the communion dimension, there is adaptivity when both persons reveal a similar high or low orientation in communion (i.e. friendly). Using this theory, Ma and Dubé (2011) for example considered the interpersonal relation between a service employee in a rehabilitation home for elderly people and an elderly person adaptive, when one of them showed a dominant and the other a submissive role towards the other.

Interactive Alignment Theory (Pickering & Garrod, 2004) also substantiates the sameness type of relatedness and provides a predefined norm for adaptivity. It was found to be used to frame the concepts of adaptation, alignment, calibration, and match. The theory posits that: (1) the goal of interaction is to achieve mutual understanding, and, (2) people automatically align their language at several linguistic levels (e.g. lexical, syntactical, etc.). Some authors describe that this alignment increases over time (e.g. Richardson et al., 2014) and others indicate that 'alignment should occur in any conversation where there are similarities between interlocutors, due to their shared backgrounds and knowledge and similarities in language processing' (Trofimovich & Kennedy, 2014, p. 823). The adaptivity norm that is derived from this theory claims that peoples' linguistic actions, at one or more linguistic levels, is or tends to become similar during interaction. Trofimovich and Kennedy (2014), for example, determined that there was adaptivity (alignment) when there was a higher degree of similarity in, amongst others, accent and fluency of the peoples' speech at the end of the conversation compared to the beginning of it.

Another theory that substantiates the sameness type of relatedness also provides a predefined norm as to what is seen as adaptive: Communication Adaptation Theory (CAT) (e.g. Giles et al., 1991). CAT was used in studies focusing on the concepts of alignment, coordination, matching, and synchrony. Similar to Interactive Alignment Theory (IAT), CAT posits that interaction becomes

more adaptive when people's behaviour becomes more similar. In contrast to IAT, CAT assumes that people (either both people that interact or just one) use strategies to negotiate distance in social relationships and that the process may thus be more deliberate than is assumed in IAT (although CAT acknowledges that the evaluation of attaining goals can also be unconscious). The negotiation of distance is done through convergence (one or several behaviours become more or even fully similar to each other) or divergence (one or several behaviours actions become less similar to each other) with the latter expressing non-adaptive behaviour (or non-accommodation, cf. Giles & Gasiorek, 2013). Using (amongst others) CAT, Richardson et al. (2014) showed that interrogators' and suspects' verbal behaviour (i.e. style and function words such as adverbs, articles, conjunctions, verbs) became more adaptive (matched) during interrogations. Taken together, the Interpersonal Theory, IAT, and CAT provide substantiation for the sameness (Interpersonal Theory, IAT, and CAT) and oppositeness (Interpersonal Theory) type of relatedness.

Apart from actions of people being similar or opposite, we also encountered studies that focused on dissimilar acts of people in describing adaptivity (23%): i.e. *specified attentiveness*. In this third type of relatedness, people's actions are dissimilar, but not necessarily opposite. This type of relatedness explains how people who are interacting with each other are oriented to one another. An example is the study of Chang et al. (2016) who considered a mother-child relation to be adaptive when the mother changed her utterance or naming rate as a function of her infant's current or recent gaze target. And Beebe et al. (2008), for example, considered a mother-child relation to be adaptive when the infant's vocal affect predicted the mother's touch. In contrast to sameness and oppositeness, for specified attentiveness researchers need to determine and argue more contextually how the interaction needs to be qualified to be seen as adaptive.

This type of relatedness is generally substantiated by using general process theory about what constitutes interpersonal relationships. These process claims then need to be translated by researchers to their specific research context. An example of such process theory is the Dynamic Systems Theory (DST) (e.g. Thelen & Fogel, 1989; Van Geert, 1994), used in 15 studies, to derive relatedness when conceptualizing adaptation, co-construction, coordination, coregulation, mutuality, scaffolding, and synchrony. DST postulates that people are interdependent in how they think and act: that is, people continuously and mutually inform and depend on each other. It states that over time, relations between people tend to become more and more stable, as people collectively shape routines towards which each individual in relation with others is pulled. Hence, the context sets the scene for future states and further moment-to-moment (inter)actions. In substantiating their specified type of relatedness, using DST, Ensing et al. (2014), for example, determined that there was adaptivity (scaffolding) when, after being provided with support of a teacher as a response to a student asking for help, the child showed a correct performance. Also using DST, Herbers et al. (2014) considered the interaction between a mother and a child adaptive when the child was withdrawn/distracted while the mother showed positive control (i.e. 'teaching, encouraging, guiding, limit-setting, and directing the child through low-to-moderate power assertion,' Herbers et al., 2014, p. 422). In both examples, the people's actions are different but not opposite and the combination of these actions is seen as adaptive.

Summarizing, maybe inherent to the nature of specified attentiveness being context-dependent, we did not encounter theories that explicitly focus on the notion of specified attentiveness or people's actions being dissimilar from each other (but not opposite). Although CAT states that adaptivity depends on contextual factors, it still considers actions that are more similar as adaptive. Yet, general process theories such as the Dynamic Systems Theory do stress that over time, people develop routines. This notion substantiates and explains why people's dissimilar actions can be seen as adaptive.

Responsivity

Conceptualization of adaptivity did not only differ in terms of the qualification of relatedness between people, they also differed with regard to the assumed or observed responsivity, that is,

the timing of people's actions. Two types of responsivity could be discerned in our sample: *reactivity* and *co-occurrence* in people's actions (see [Tables 3](#) and [4](#)). Most studies (62%) determined responsivity in terms of subsequent acts of people (i.e. reactivity). They did so either unilaterally (focusing on the response of one person to the other person), or bilaterally (focusing on the mutual responses). In these studies, it is assumed that one examined whether people react to each other and thus include observations of people's acts at multiple points in time. Focusing on relatedness in terms of sameness, Allen et al. (2011), for example, investigated to what extent the syntactic structure of a child's response was similar to the syntactic structure of the experimenter in the child's responses *following* the experimenter's prompts. Focusing on oppositeness, Sarangi et al. (2005) saw adaptivity in the response of a client giving an answer to a counsellor who had just asked a question. Similarly, focusing on relatedness in terms of specified attentiveness, Lundy (2013) determined adaptivity when the parent's specificity level of their intervention increased over *time in response* to their child's low competence level or decreased over time in response to their child's high competence level. Interpersonal theory, for example, substantiates this type of responsivity, as this theory assumes that behaviour of one person *elicits* behaviour of the other person (e.g. Pennings et al., 2018).

In some studies, whether responses are actually due to the actions of the other is the topic under investigation. Different analytical or statistical approaches are used to approach that question. Vuchinich et al. (1991), for example, used sequential analyses to study the reciprocation of mothers' behaviour after the child has shown similar behaviour as it 'can distinguish the overall frequency of occurrence of a behaviour from the tendency to reciprocate a behaviour.' (p. 626). In other instances, a specific time-lag is considered to ensure that certain actions are a response to previous ones of the other person. Heerey and Crossley (2013) for example indicated that a smile was reactive (rather than anticipated) when the time lag between the onset of an individual's smile and the onset of the conversation partner's smile was more than 200 ms as this is 'the minimum time required to process and respond to a complex stimulus with a complex voluntary movement (Sanders, 1998)' (p. 2). Finally, some studies used statistical models to determine whether people react to each other. Eastwick et al. (2007) used Kenny's Social Relation Model (Kenny, 1994) to statistically distinguish, amongst others, between people's general tendencies of liking other potential romantic partners (during speed-dating), being liked, or liking a specific other person while this specific person also likes him/her with the latter indicating adaptive actions.

A smaller group of studies (32%) conceptualized adaptivity as *co-occurring* actions of people, considering what different people do in the same moment or period. Sometimes, an already developed adaptive relation is assumed to underlie the observed interaction, e.g. a shared history in the given relation. Dynamic Systems Theories (including e.g. transactional models of development, ecological dynamics perspectives) substantiate this idea, given that Dynamic System Theory assumes that people form interaction patterns or routines that become stable over time (e.g. Van Geert, 1994). The more established this pattern becomes, the more people know how others will respond and the more people can anticipate on each other's behaviour. Bernard et al. (2017), for example, established the similarity of a mother's and her child's cortisol levels at, amongst others, one time-point, and substantiate this focus on one time-point by stating that attunement is often seen as 'a reflection of a more stable characteristic of how the dyad typically responds to stressful events' (p. 175).

Other times, co-occurrence is seen as adaptive because people orient their attention to the other or to a shared object in the situation, establishing an immediate and shared state of attentiveness. That is, it is assumed that people respond 'to the fact that agents are sharing the same environment and thus follow the same environmental motor cues (affordances)' (Sacheli et al., 2012, p. 1). An example is simultaneous laughing of tutor and student, which is seen as a common response to something (e.g. an utterance of one of the persons) that happened in the interaction (Thonus, 2008). Sociocultural theories (e.g. Vygotsky, 1978), used in five studies that conceptualized adaptivity as a co-occurring event, stress that children learn in dyadic interactions with their caregiver and triadic interactions with their caregiver and an object (e.g. a toy). Maintaining joint attention towards the object is often considered adaptive and conducive to children's (linguistic) development (e.g. Adamson et al., 2014; Legerstee et al., 2007).

But most often (13 times), when adaptivity is conceptualized as the co-occurrence of people's behaviour, this is substantiated using biological models, that is, models that conceptualize adaptivity as innate, biologically driven and (sometimes) automatic and unintentional (e.g. Chapple, 1982; Cappella, 1981; Feldman et al., 2013; Trevarthen, 1998). Co-occurrence of people's acts occurs, according to these models, through neural mechanisms that cause people's acts or behaviour to be cyclical or rhythmic (e.g. Bernieri & Rosenthal, 1991) and co-occurrence of people's acts and coupling of rhythms occurs as early as 20 min after birth fulfilling basic needs such as bonding and safety (cf. Burgoon et al., 1995). In addition, these models also acknowledge that co-occurrence of people's acts may facilitate interaction (e.g. Bernieri & Rosenthal, 1991). Kokkinaki (2010), using the theory of (innate) intersubjectivity (Trevarthen, 1998), consider father and infant's acts to be adaptive when they co-occur (e.g. co-occurrence of the same facial expression at the same moment in time). Acts can co-occur 'through imitation of internal motives that each partner is regulating the dynamics of consciousness and purpose, emotional empathy and reciprocal communication.' (Kokkinaki, 2010, p. 88).

The two dimensions, relatedness and responsivity are distinct from each other. Relatedness refers to *how* people's actions should relate to each other to be adaptive whereas responsivity refers to the *timing* of people's actions. When relatedness is defined (e.g. people's actions should be similar), this says nothing about the timing of people's actions. So to determine adaptivity, both relatedness and responsivity need to be specified. That is, one always need to specify how people's actions should relate to each other (comparing similar, opposite, or dissimilar actions) *and* what timing is assumed to indicate adaptivity (i.e. actions that follow-up) on each other (i.e. reactivity) or co-occurrence of peoples' actions.

Positioning of concepts

Combining the relatedness and responsivity dimensions resulted in a multiconceptual framework (Tables 3 and 4). Supplemental material B shows per study how each adaptivity indicator was classified (last column). Classification of the adaptivity indicators did not show a clear clustering of concepts within one part of the framework, meaning that concepts are currently not used unequivocally (Table 4).

Overall, sameness and reactivity are most frequently used. More specifically, based on the adaptivity indicator numbers, adaptivity is most frequently (40%) described as a phenomenon where people show similar acts subsequently (i.e. sameness + reactivity). Adaptivity is least often (2%) described as co-occurrence of opposite behaviour. Noteworthy is how adaptivity was relatively often (22%) described as attentiveness of people showing very dissimilar acts at different points of time. This indicates how adaptivity does not need to concern actions of people in defined directions but rather can indicate, more basically, people acting with careful orientation or sensitivity to the other and the situation.

Although most concepts were described very ambiguously, there were two exceptions.³ First, the concept of *imitation* (e.g. imitative language, vocal imitation) was solely conceptualized as *sameness* between people being *reactive* (i.e. giving a reaction or response of one person that is the same as the act of the other person). Second, the concept of *uptake* was exclusively conceptualized as being *reactive* with a *specified* combination of actions, such as teacher feedback followed by a correct reformulation of the student's error (Choi & Li, 2012). The least consistently employed concept was that of *attunement*; it occurred in each cell of our framework (Table 4). For example, attunement is used for the co-occurrence of specific actions of one person during specific actions of the other person (a mother's high intensity and duration of affective actions, tone of voice, and use of affective words during her infant's nonverbal signals; Bartling et al., 2010), for reacting with the same actions upon the other persons' actions (people showing high levels of empathy; Griffiths & Smith, 2016), or for reacting with opposite actions (an infant reacting with a change in the respiratory sinus arrhythmia that is opposite to the change that is shown previously by the mother; Ostlund et al., 2017).

Discussion

To describe adaptivity in face-to-face interaction, a myriad of concepts and theories have been used in the literature, which stresses both the significance and the complexity of the phenomenon. With this large-scale scoping review, we aimed to understand the phenomenon of adaptivity in face-to-face interaction. We synthesized different aspects of as many as 33 different adaptivity concepts from different situations and different research areas (i.e. Communication, Education, Health Care, Linguistics, Psychology, Psychiatry, and Sociology) into a theory-based conceptual framework with two core dimensions of adaptivity.

The first dimension was *relatedness*. That is, the conceptualization of the appropriate way of how people relate to one another in a given situation and thus refers to *how* people's actions should relate to each other in order to be adaptive. Relatedness was considered in terms of: (a) sameness in people's actions (e.g. both people act friendly), (b) oppositeness in people's actions (e.g. one person acts dominantly and one person acts submissively), or (c) specified attentiveness (how people are oriented to each other while showing dissimilar acts). The second dimension was *responsivity*, which refers to the sequentially of the relatedness and thus refers to the *timing* of people's actions. Responsivity either took the form of reactivity (subsequent acts of people with unilateral or bilateral influence), or co-occurrence (considering what different people do simultaneously). Relatedness thus refers to how people's actions should relate to each other in order to be adaptive whereas responsivity refers to the timing of people's actions.

Together, the dimensions form a theory-based conceptual framework of adaptivity (Tables 3 and 4). Some distinctions made in this conceptual framework connect to distinctions made in previous work. Bernieri and Rosenthal (1991) distinguished four manifestations of interpersonal coordination and conclude that one (i.e. simultaneous movement) is characterized by co-occurrence of two or more actions, whereas the others are not (i.e. behaviour matching, interactional synchrony, and behavioural meshing). Also, Burgoon et al. (1995) distinguished mutual (i.e. bidirectional) and unidirectional influence between people's actions. The current conceptual framework integrates and extends these insights in a way that could streamline future adaptivity research. The use of the framework encourages transcending the concept-level (e.g. only using theory and empirical research that uses one particular concept) and describing the adaptivity phenomenon of interest in terms of its dimensional characteristics.

The findings of this review have fundamental implications for further research on adaptivity. The framework can help in conceptualizing, operationalizing, and analysing the phenomenon of interest. The dimensions provide researchers from different disciplinary fields with unified analytic language to explicate their choices in their conceptualization, operationalization, and analyses of adaptivity. It is beyond the scope of the current review to list all ways of operationalizing and analysing each dimension; yet, we do reflect here on the considerations that play a role within the different dimensions and on some examples of analyses that could be used.

For the sameness and oppositeness type of relatedness, researchers need to substantiate why acts that are similar or opposite respectively are the recipe to being adaptive in a given situation. Interactive Alignment Theory (IAT) and Communication Adaptation Theory (CAT), for example, help in substantiating the sameness type of relatedness. They posit that behaviour is adaptive when it is or becomes more similar; people engage in similar behaviour either automatically (IAT) or more conscious and purposeful (CAT) to increase mutual understanding, which is, according to these theories, the goal of interaction. Interpersonal Theory substantiates both the sameness and the oppositeness type of relatedness by positing that friendly behaviour of one person elicits friendly behaviour of the other but dominant behaviour of one person elicits submissive behaviour of the other. People who are behaving in this adaptive manner tend to have smooth interpersonal relations. In operationalizing the sameness type of relatedness, one should define carefully what actions are observed and coded and preferably use the same criteria for observing the actions in both persons involved. For the opposite dimension, researchers should make very clear in their

codebook what actions are seen as opposite of other actions. The interpersonal circle, for example, (e.g. Kiesler, 1983), that is used in Interpersonal Theory, provides a description and examples of behaviours that are similar (sameness) and dissimilar (oppositeness) to each other.

For specified attentiveness, the challenge is to substantiate why a particular combination of people's dissimilar acts is considered adaptive. Dynamic Systems Theory substantiates this type of relatedness as it states that interactions and relationships become more stable over time, and that people jointly create routines. So, any combination of two people's dissimilar behaviours could become adaptive, when their relationships stabilize. Yet, some other questions that are not necessarily directly addressed by theory but that may be addressed in future research and theory development are: 'Does it matter what the interaction is about for similar/opposite acts to be adaptive?' 'how can we improve interactions and relationships by creating (in)stability in interactions?' and 'When are people's acts considered same/opposite and why (e.g. is smiling the same as laughing out loud?).'

For reactive responsivity, researchers need to substantiate why acts that follow each other are adaptive. Interpersonal Theory assumes that adaptive behaviour consists of a person's specific behaviour (e.g. dominant behaviour) that initiates, invites, or invokes the other person's specific behaviour (e.g. submissive behaviour) and behaviour is thus sequential. Questions that deserve attention of future research and theory development are: 'When, why, and how do researchers establish that one act is actually a response to a previous act rather than an anticipation of a subsequent act, especially when acquaintances are interacting?' and 'What actions shown within what time-frame are indicative of a response and with what time-frame they are no longer considered responses (e.g. Can people for example be slow or late in their response)?' Analyses that are used for this dimension should fit the nature of the dimension, that is, that actions follow each other and are analysed as following each other. For this dimension, at least two time-points need to be considered. Sequential analyses (Bakeman & Gottman, 1997; Yoder & Tapp, 2004) or time-series analyses, such as spectral analysis (Pennings et al., 2018; Warner, 1998) or State Space Grid analysis (Hollenstein, 2007; Lewis, Lamey, & Douglas, 1999) could be useful in this regard as well as Social Relation Models (Kenny, 1994) that can help to determine whether people actually react to each other. Yet, there are more types of analyses that can be suited, for example more qualitative and descriptively oriented analyses (e.g. orbital decomposition analysis; Guastello et al., 1998).

Finally, for co-occurring responsivity, researchers need to substantiate how acts that occur at the same point in time can be adaptive. From a Dynamic Systems perspective, it is assumed that interaction patterns become more stable over time and that people can anticipate more on each other's behaviour. From a Sociocultural perspective, it is assumed adaptivity emerges by the situational features of the interaction (e.g. an object that both persons orient to, the context that evokes a particular social or cultural script). From a Biological perspective, it is assumed that people's acts become cyclical or rhythmic through neural mechanisms. Questions for future research and theorizing could be: 'Why or how can one assume that adaptivity has already been established in this relation?' 'Why is the specific timeslot of the study then suitable to observe adaptivity?' and 'Is the adaptive relation fully established or still developing?' This dimension probably requests partly different analytic approaches than the reactivity dimension. In contrast to the reactivity dimension, focusing on one time-point/interval suffices (although it is also possible to involve more time-points and investigate co-occurrence at different time points). Operationalisations and analyses of this dimension should enable the researchers to determine the simultaneity of people's actions, e.g. by assigning codes to videos of interaction with regard to particular actions at specific time-points. Subsequently, the time-points can be compared as to determine whether people's actions occurred simultaneously. Analytical techniques that can be used are lagged Cross-Correlations (Sadler et al., 2009), Cross-spectral analysis (Pennings et al., 2018; Sadler et al., 2009), Cross-Recurrence Quantification Analysis (Cox et al., 2016).

The conceptual framework presented here can be a heuristic for making choices in how to conceptualize, operationalize, and analyse adaptivity, and for connecting own research to a wider body

of literature. Carefully substantiating choices in conceptualization, operationalization, and analyses, using theory where possible. This is crucial as it provides researchers with a better understanding of the phenomenon under study than when relying and building on literature and conceptualization of one particular concept only. Given the unequivocal use of each concept, relying only on research using a particular concept would hamper use and integration of the full body of knowledge that is already present in research literature. Placement of the adaptivity concepts in our conceptual framework showed that the great majority of the concepts are described in numerous different ways (with the exceptions of the concepts of imitation and uptake). Compared to Burgoon et al. (2017), who state that researchers of communication, psychology, and linguistics have agreed consensus on the meaning of several concepts (e.g. matching, mirroring, reciprocity), our findings sketch a less optimistic picture, that is, ambiguous use of several concepts.

Limitations and future research

The goal of this review was not to provide an exhaustive overview of the literature on adaptivity in f2f-interaction. Rather, our main aim was to distil the essence of adaptivity across studies from a multitude of disciplinary fields. Future research could further validate this framework by investigating to what extent additional conceptualisations of adaptivity not included in this review fit within our conceptual framework. Given that after a while, no new dimensions occurred in our analysis, we do not expect to have omitted a major dimension. However, it may be the case that some dimensions may be further specified, e.g. according to contextual factors (e.g. hierarchy, degree of acquaintance, etc.).

Our conclusions regarding separate concepts, need to be interpreted with caution given that our review was not exhaustive. In our data, for example, imitation and uptake were relatively homogeneously described. Future research could establish whether this conclusion still holds when categorizing more studies focusing on these concepts.

In addition, not all adaptivity indicators could be placed into one of the cells of our framework (7% of the indicators). Those that could not be placed into one of the cells were placed in the mixed/other category. The need of such a category stresses the fact that adaptivity is a diverse and complex phenomenon. It also stresses that continued investigation around the ambiguity of adaptivity concepts is needed.

Finally, we did not assess determinants, mechanisms, or outcomes of adaptivity in this review. The conceptual framework developed in the current review could be used as a starting point for a meta-analysis, testing such determinants, mechanisms, and outcomes of adaptivity while transcending the concept level and including and/or comparing research that pertains to adaptivity with the same dimensional characteristics (instead of including only research of a particular concept).

Conclusion

In conclusion, although our findings demonstrate that descriptions of adaptivity within and between concepts are too diverse to extract one shared conceptualization of adaptivity in face-to-face interaction in general or for separate adaptivity concepts, our review helps to understand and explicate the essence of the phenomenon of adaptivity in face-to-face interaction. That is, adaptivity should always describe the appropriate way how people relate to each other in a given situation (with the appropriate way being similar, opposite, or dissimilar actions) and the co-occurrence or sequentially of people's responses (i.e. responsivity). As such, this review provides researchers from different disciplinary fields, such as Communication, Education, Health Care, Linguistics, Psychology, Psychiatry, and Sociology with a theory-based tool for streamlining adaptivity research and a unified language to address adaptivity.

We encourage researchers to reach beyond their own field and engage interdisciplinary with researchers from these different research fields to get a deeper understanding of the adaptivity concept of interest. This may help researchers to place their adaptivity concept of interest in the

conceptual framework and subsequently contrast research that is encountered to the dimensional characteristics of the positioned concept to decide whether the research encountered pertains to the same adaptivity phenomenon. The review also showed what theories underpin which dimension of the conceptual framework. Coherent understanding of adaptivity and the possibility for researchers to benefit from each other's knowledge facilitates sound empirical research, which in turn can be used to bolster adaptive practices in face-to-face interactions in different disciplinary fields.

Notes

1. We explored the concepts relatedness, flexibility, tailor, anchored instruction, heterogeneity, contextuality, cohesion, synergy, formative assessment, and sharing, but excluded these as initial searches yielded (almost) no relevant hits.
2. From here on, we will refer to cognitions, behaviour, and/or emotions as actions.
3. We restricted ourselves in this analysis per concept to concepts with ≥ 10 relevant hits, resulting in 17 concepts (Table 1). With <10 hits, it was hard to evaluate how a concept was described in the literature.

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